THE STARS AND CONSTELLATIONS

HOW AND WHEN TO FIND AND TELL THEM.

By W. H. ROSSER.

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AND

CONSTELLATIONS;

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TO FIND AND TELL THEM.

BY

W. H. ROSSER,

Author of "The Law of Storms Considered Practically," and "The Deviation of the Compass in Iron Ships."

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"———Seemed it that the way
Lay through the midst of an immense concave
Radiant with million constellations, tinged
With shades of infinite colour.

* * * * *

There, far as the remotest line
That bounds imagination's flight,
Countless and unending orbs,
In mazy motion intermingled,
Yet still fulfilled immutably
Eternal Nature's law.
Above, below, around,
The circling systems formed
A wilderness of harmony;
Each with undeviating aim,
In eloquent silence, through the depths of space
Pursued its wond'rous way."—SHELLEY.

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PREFACE.

The following pages were originally written to illustrate a New Set of Star-Maps issued by Charles Wilson (Late J. W. Norie and Wilson), and being intended for sea-use, various Stellar Problems in Navigation were introduced.

But much of the work—that relating to the recognition of the face of the heavens, by the use of the Maps—being equally available to give the landsman a knowledge of the Stars and Constellations, that part is now issued in a cheaper form. It is hoped that a careful perusal of the text, with a judicious examination of the Star-Maps, will give the novice in Astronomy as good an idea of *how to find and how to tell the stars* as any other book intended for that purpose.

The Maps could not be sold detached from the book, without adding to the expense; but as some students may find it advisable to cut them out, in order to use them efficiently, it is recommended to back them on calico; they can then be turned about and around as required, and afterwards folded up and replaced in the cover without injury.

Carefully read through the whole work; and then, when intending to use the Maps, to gain a practical knowledge of the constellations, refer to pp. 25-29 for full instructions on this head.

W. H. R.

London, *January*, 1879.

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THE STARS AND CONSTELLATIONS.

CHAPTER I.

PRELIMINARY AND HISTORICAL REMARKS.—THE CONSTELLATIONS, ANCIENT AND MODERN.—CATALOGUE OF THE NORTHERN, ZODIACAL, AND SOUTHERN CONSTELLATIONS.—THE PRINCIPAL FIXED STARS, THEIR PROPER NAMES AND MAGNITUDES.—COLOUR OF THE FIXED STARS.—VARIABLE STARS.—DOUBLE AND MULTIPLE STARS.—PARALLAX AND DISTANCE OF THE STARS.—PROPER MOTION OF THE STARS.—THE MILKY WAY.—NEBULÆ, &c.

THE **Solar System** is the general term applied to the assemblage of planets (with their *satellites* or moons), comets, meteors, and other cosmical bodies that revolve, at various distances, around the Sun as a centre. To this system belongs our Earth; and the planets in the order of their proximity to the Sun are—Mercury, Venus, the Earth, Mars, the Asteroids, Jupiter, Saturn, Uranus, and Neptune. Those moving in orbits (or *paths*) between the Sun and the Earth are called *inferior planets*, those beyond the Earth are the *superior planets*. All revolve round the Sun in the same direction as the Earth, but in different periods of time, and they are bodies which, like the moon, shine by light received from the Sun, and which is reflected to us. Some of these planets, as Venus, Jupiter and Mars, are at times peculiarly bright,—the first two indeed generally brighter than any other of the celestial objects in their apparent vicinity,—and they are familiarly designated as stars; but they are not such, except in the abstract definition of the dictionary—"*star*, a luminous body in the heavens."—There is no intention to treat at any length on the different members of the solar system, although they will incidentally be noticed, and in such a manner as to enable the reader to find them in their various positions as they appear to thread their way along the starry firmament, for they are in no way connected with any particular group of stars, but are now found in one constellation, and now in another.

From an astronomical stand-point a star is a body that shines by its own light, and hence by analogy is like our own Sun.

And what is a **Fixed Star**?—"The innumerable multitude of the stars which are distributed over the vault of the heavens preserve, not only to the eye of the casual observer, but to the nice examination of the astronomer, uniformity of aspect which, when contrasted with the perpetual change in the configurations of the sun, moon, and planets, may well be termed invariable. It is true, indeed, that by the refinement of exact measurements prosecuted from age to age, some small changes of apparent place, attributable to no illusion and to no *terrestrial* cause, have been detected in some of them; but these are so excessively slow, that their accumulated amount (even in those stars for which they are greatest) has been insufficient, in the whole domain of astronomical history, to produce any obvious or material alteration in the appearance of the starry heavens. This circumstance, then, establishes a broad distinction of the heavenly bodies into two great classes:—The *fixed*, among which (unless in a course of observations continued for many years) no change of mutual situation can be detected; and the erratic, or wandering (which is implied in the word planet) including the sun, moon, and planets, as well as the singular class of bodies termed comets, in whose apparent places among the stars, and among each other, the observation of a few days, or even hours, is sufficient to exhibit an indisputable alteration."—Sir John Herschel's, *Treatise on Astronomy*.

Thus, then, the Fixed Stars are those bodies in the heavens which are observed to preserve always the same situation with respect to one another. In no other sense are they *fixed*, for nothing in nature is in repose.

To other worlds our Sun is a *fixed star*; he shines by his

own light, and traverses space accompanied by a planetary system to which he communicates both heat and light; so, in a similar manner, the multitude of fixed stars that deck the canopy of heaven are so many self-luminous suns—each one of them probably the centre of a system of planets, the dwelling places of sentient and intelligent existences.

Constellations.—When, where, under what circumstances, and for what special purposes, if any, names were first given to star-groups is now unknown; but it is certain that, whether for astrological or astronomical investigations, the stars must have been classified, both as regards their grouping and magnitudes, at a very early date. The Chaldeans, Chinese, Indians, and Egyptians seem to have obtained considerable celebrity for astronomical knowledge at a very remote antiquity, and some of their records refer to a date of about 2,000 to 3,000 years before the Christian era—periods of antiquity far beyond reasonable probability; but still, though these extravagant claims are unsupported by sufficiently good evidence, the subject must have made some progress among them upwards of a 1,000 years before our era. Their early observations, though of a rude description, possess a peculiar interest, inasmuch as they furnished the first materials for those comparisons of the state of the heavens at distant periods, by which the great progressive changes in our system have been brought to light.

In order, then, to recognise the fixed stars, the heavens were mapped out into constellations or groups of stars, in which, by the aid of a fertile imagination, some resemblance was traced out in the configuration to the shapes of the various objects whose names were assigned to them. The most ancient records allude to them by those distinctive names. In the Old Testament, in the Book of Job, we read of the "bands of Orion" and "the sweet influences of the Pleiades;" and in Hesiod and Homer are names as familiar to the astronomer of to-day as to the observer in the ages when science was young, and in its dawn.

The classification of the stars into constellations, as now adopted, is purely arbitrary, and is far from being as simple as it might be. As Sir John Herschel observes, "they seem to have been almost purposely named and delineated to cause as much confusion and inconvenience as possible. Innumerable snakes twine through long and contorted areas of the heavens, where no memory can follow them; bears, lions, and fishes, large and small, northern and southern, confuse all nomenclature." A uniform system of grouping and naming was the great desideratum, to aid the astronomer in communicating what he had observed, and to assist the memory. If the end has been but very inadequately attained, it is impossible now to alter an arrangement that has been in existence, and recognised by all civilised nations, for centuries.

The admitted makers of constellations are Aratus, Ptolemy (P) of Alexandria, Bayer (B), Hevelius (H), and Lacaille (L). The ancient constellations that come through Aratus and Ptolemy show that, as regards configuration and nomenclature, their base was the Grecian mythology. But many groups of stars still remained unnamed, and these were formed into constellations by Bayer, Hevelius, and Lacaille: to the latter list Tycho Brahe (T), Lemonnier (Le), and Poczobut (Po), have each added one group, and Halley (Ha), two groups. The constellations proposed by Bode (Bo), Hell, Lalande (La), and others are not generally recognised.

The initials attached to the constellations indicate with whom they originated.

ANCIENT CONSTELLATIONS
OF ARATUS AND PTOLEMY.

Andromeda
Aquarius
Aquila
Ara
Argo Navis
Aries
Auriga
Boötes
Cancer
Canis Major
Canis Minor (P)
Capricornus
Cassiopeia
Centaurus
Cepheus
Cetus
Corona Australis (P)
Corona Borealis
Corvus
Crater
Cygnus
Delphinus
Draco
Equuleus (P)
Eridanus
Gemini
Hercules
Hydra
Leo
Lepus
Libra
Lupus
Lyra
Ophiuchus
Orion
Pegasus
Perseus
Pisces
Piscis Australis
Sagitta
Sagittarius
Scorpio
Serpens
Taurus
Triangulum
Ursa Major
Ursa Minor
Virgo

Some of the above constellations had other names at different dates, thus Arctophylax is Boötes, Engonasin is Hercules, Gallina is Cygnus, Serpentarius is Ophiuchus, and Vultur is Aquila.

MODERN CONSTELLATIONS.

Antlia Pneumatica (L)
Apis (B), *see* Musca
Apparatus Sculptoris (L)
Apus, or Avis Indica (B)
Cælum Scalptoris (L)
Camelopardus (H)
Canes Venatici (H)
Chamæleon (B)
Circinus (L)
Columba (Ha)
Coma Berenicis (T)
Crux (Ha)
Dorado (B)
Equuleus Pictoris (L)
Fornax Chemica (L)
Grus (B)
Horologium (L)
Hydrus (B)
Indus (B)
Lacerta (H)
Leo Minor (H)
Lynx (H)
Mieroscopium (L)
Monoceros (H)
Musca (L), or Apis (B)
Norma (L)
Octans (L)
Pavo (B)
Phœnix (B)
Piscis Volans (B)
Pyxis Nautica (L)
Reticulum (L)
Scutum Sobieski (H)
Sextans (H)
Solitarius (Le)
Taurus Poniatowski (Po)
Tubus, or Telescopium (L)
Toucanus (B)
Triangulum Australe (B)
Vulpecula et Anser (H)

Many other constellations have, at different times, been proposed, and occasionally admitted into catalogues, but these are now generally discarded, such as Antinous (T), Asterion et Chara (same as Canes Venatici), Brandenburgium Sceptrum (Bo), Caput Medusæ, Cerberus (H), Cor Caroli (Ha), Custos Messium (La), Gloria Frederici (Bo), Machina Electrica, Mons Mænalus (H), Mons Menæ (L), Musca Borealis (Bo), Passer (same as Piscis Volans), Psalterium Georgianum of Hell, Praxiteles (the same as Cælum Scalptoris), Quadrans (Bo), Robur Caroli (Ha), Tarandus (Le), Telescopium or Tubus Herschelii (Bo), Triangulum Minus (H), and Xiphias (same as Dorado).

To these may be added the Press of Gottenburg, the Air Balloon, the Cat, the Log-line, the River Jordan, the River Tigris, the Fleur-de-luce, the Ring, the Armilla, &c., &c., a list too long to continue, for towards the close of the last century, constellation making was a favourite amusement with some astronomers.

It may, in passing, be observed that among the various attempts made in the Middle Ages to change the system of star-grouping, some of them, if not absurd, are sufficiently amusing; thus a few pious astronomers scandalized at the employment of the names of fabulous divinities and heroes, adopted a spiritual sense, where that was possible,—for instance making Aries stand for the ram sacrificed by Abraham in the place of Isaac, and the Venerable Bede gave the names of the twelve Apostles to the twelve zodiacal signs; in this manner the profane was swept away, and an entirely new nomenclature for the constellations was adopted. On the other hand Weigelius of Jena adopted a heraldic principal, substituting for the constellations the arms of various European princes, and the insignia of the various guilds; on this principle Ursa Major become the elephant in the Danish arms, &c. But all this has passed away and is now matter of history, while the reign of Orion, Boötes, Perseus and Pegasus still survives.

The formation of a systematic catalogue of constellations and stars dates from the time of Ptolemy in 138, and is found in his "Almagest," being compiled from the observations of all earlier astronomers. There is no other ancient catalogue. In the 15th and 16th centuries came the catalogues of the Persian prince Ulugh Beigh and Tycho Brahe. The catalogue of Bayer dates from 1603, and that of Hevelius from 1690. All these were made without the aid of the telescope. After the invention of that instrument observations became more exact, and the more important catalogues are those of Halley, Flamsteed, Bradley, Bessel, Lacaille, Piazzi, Groombridge, and Lalande. On their researches Baily compiled, in 1827, the Astronomical Society's catalogue, which has been followed by that of the British Association, and by others equally valuable and comprehensive.

It remains now to give a complete catalogue of the constellations in the order (approximately) of their declinations from north to south. The principal stars in the order of their right ascensions, as given in the *Nautical Almanac*, will be found in Table 1—"Mean Places of Stars."

The constellations north of those called *Zodiacal* are known as the *Northern Constellations*; those to the south of the same are the *Southern Constellations*.

In each list are given—the astronomical Latin names of the constellations, the corresponding English names, and the Genitives of the Latin names, which is the form used in conjunction with letters or numerals to distinguish particular Stars forming the constellations.

The modern constellations are here denoted by an asterisk, thus *; and these, as might be expected, are most numerous in the southern portion of the celestial concave.

NORTHERN CONSTELLATIONS.

Astronomical Latin Names.	English Names.	Genitives of Latin Names.	Dec. °
Ursa Minor	Little Bear	Ursæ Minoris	75 N
Camelopardus*	Cameleopard	Camelopardi	70
Draco	Dragon	Draconis	66
Cepheus	Cepheus	Cephei	65
Ursa Major	Great Bear	Ursæ Majoris	60
Cassiopeia	Cassiopeia	Cassiopeiæ	60
Lynx*	Lynx	Lyncis	50
Perseus	Perseus	Persei	49
Auriga	Charioteer	Aurigæ	45
Lacerta*	Lizard	Lacertæ	42
Cygnus	Swan	Cygni	42
Canes Venatici*	Greyhounds	Canum Venaticorum	40
Lyra	Lyre	Lyræ	38
Leo Minor*	Little Lion	Leonis Minoris	35
Andromeda	Andromeda	Andromedæ	35
Corona Borealis	Northern Crown	Coronæ Borealis	30
Triangulum	Triangle	Trianguli	27
Coma Berenicis*	Berenices' Hair	Comæ Berenicis	26
Vulpecula et Anser*	Fox and Goose	Vulpeculæ-Anseris	25
Hercules	Hercules	Herculis	22
Boötes	Boötes	Boötis	20
Sagitta	Arrow	Sagittæ	18
Delphinus	Dolphin	Delphini	15
Pegasus	Pegasus	Pegasi	14
Equuleus	Little Horse	Equulei	11
Taurus Poniatowski*	Poniatowski's Bull	Tauri Poniatowski	7
Aquila	Eagle	Aquilæ	5
Ophiuchus	Ophiuchus	Ophiuchi	0
Serpens	Serpent	Serpentis	0

CONSTELLATIONS OF THE ZODIAC.

	Astronomical Latin Names.	Signs.	English Names.	Genitives of Latin Names.
Northern.	Aries	♈	Ram	Arietis
	Taurus	♉	Bull	Tauri
	Gemini	♊	Twins	Geminorum
	Cancer	♋	Crab	Cancri
	Leo	♌	Lion	Leonis
	Virgo	♍	Virgin	Virginis
Southern.	Libra	♎	Balance	Libræ
	Scorpio	♏	Scorpion	Scorpii
	Sagittarius	♐	Archer	Sagittarii
	Capricornus	♑	Goat	Capricorni
	Aquarius	♒	Water Bearer	Aquarii
	Pisces	♓	Fishes	Piscium

There is an old rhyme indicating the order in the heavens of the zodiacal constellations:—

The Ram, the Bull, the heavenly Twins,
And next the Crab, the Lion shines,
The Virgin and the Scales;
The Scorpion, Archer, and Sea-Goat,
The Man that bears the Watering-pot,
And Fish with glittering tails.

SOUTHERN CONSTELLATIONS.

Astronomical Latin Names.	English Names.	Genitives of Latin Names.	Dec. °
Canis Minor	Little Dog	Canis Minoris	5 N
Orion	Orion	Orionis	0
Monoceros*	Unicorn	Monoceri	3 S
Sextans*	Sextant	Sextantis	3
Scutum Sobieski*	Sobieski's Shield	Scuti Sobieski	10
Cetus	Whale	Ceti	12
Hydra	Hydra	Hydræ	15
Crater	Goblet	Crateris	15
Corvus	Crow	Corvi	15
Lepus	Hare	Leporis	18
Canis Major	Great Dog	Canis Majoris	20
Solitarius*	Pelican	Solitarii	25
Fornax Chemica*	Chemist's Furnace	Fornacis Chemicæ	30
Pyxis Nautica*	Mariner's Compass	Pyxis Nauticæ	30
Piscis Australis	Southern Fish	Piscis Australis	30
Antlia Pneumatica*	Air Pump	Antliæ Pneumaticæ	32
Eridanus	River Eridanus	Eridani	33
Columba*	Dove	Columbæ	35
Microscopium*	Microscope	Microscopii	35
Apparatus Sculptoris*	Sculptor's Tool	Apparatûs Sculptoris	38
Corona Australis	Southern Crown	Coronæ Australis	40
Cælum Scalptoris*	Engraver's Tool	Cæli Scalptoris	40
Norma*	Square	Normæ	45
Lupus	Wolf	Lupi	45
Grus*	Crane	Gruis	45
Argo Navis	Ship Argo	Argûs	50
Centaurus	Centaur	Centauri	50
Tubus or Telescopium*	Telescope	Tubi or Telescopii	50
Phœnix*	Phœnix	Phœnicis	50
Equuleus Pictoris*	Painter's Easel	Equulei Pictoris	55
Indus*	Indian	Indi	55
Ara	Altar	Aræ	55
Crux*	Cross	Crucis	60
Horologium*	Clock	Horologii	60
Reticulum*	Net	Reticuli	62
Dorado*	Sword Fish	Doradûs	62
Circinus*	Compasses	Circini	64
Triangulum Australe*	Southern Triangle	Trianguli Australis	65
Toucanus*	Toucan	Toucani	66
Hydrus*	Water Snake	Hydri	68
Musca*	Fly	Muscæ	68
Piscis Volans*	Flying Fish	Piscis Volantis	68
Pavo*	Peacock	Pavonis	68
Apus*	Bird of Paradise	Apûs	75
Chamæleon*	Chameleon	Chamæleontis	78
Octans*	Quadrant	Octantis	80

Scintillation of the Stars.—"Among the phenomena belonging to natural and telescopic vision which are remarkable in themselves, and of which the causes are much contested, is the nocturnal sparkling (*twinkling* or *scintillation*) of the stars.

"The degree of scintillation is strikingly different in different fixed stars; not dependent solely on their altitude or their apparent magnitudes, but also, it would seem, on the nature of their particular light. Some, for example Vega, twinkle less than Arcturus and Procyon. The absence of scintillation in the planets with the largest discs is to be ascribed to compensation, and to the mixture of the colours proceeding from different points of the disc. The disc is to be regarded as an aggregation of stars, which mutually restore the light neutralised by interference, and re-combine the coloured rays into white light. Thus traces of scintillation are most rare in Jupiter and Saturn, but are seen in Mercury and Venus. In the clear cold winter nights of the temperate zone, the scintillation of the stars enhances the impression of the lustre of the starry heavens from the circumstance that, as we see stars of the 6th and 7th magnitudes shine forth suddenly here and there, we are led to imagine that we perceive more shining points than the unassisted eye can really distinguish. Hence arises the popular surprise at the few thousands of stars noted in accurate catalogues as visible to the naked eye. That the trembling light of the fixed stars distinguishes them from the planets, was clearly known to the Grecian astronomers.

"In and near the tropical zone, from the more uniform character of the atmospheric strata, the comparative or entire absence of scintillation in the fixed stars to within 12° or 15° of the horizon, gives to the vault of heaven a peculiar character of repose and tranquil brilliancy."—Humboldt's *Cosmos*.

Stars—their Names.—From a very early date the stars of most conspicuous brightness appear to have had specific names assigned to them. Many of these names have come down to us from the Greek and Arabian astronomers, but the majority of them are now discarded as inconvenient, and only nineteen are so designated in the "Nautical Almanac." The present system of nomenclature, adopted originally by Bayer in the seventeenth century, distinguishes the stars in each constellation, in the order of their brilliancy, by the letters of the Greek, Italic and Roman Alphabets, and when these letters are exhausted by numerals. The first letter of the Greek alphabet is *generally** appropriated to the brighest star of the constellation, and the second letter to the next, and so on, the Latin name of the constellation being at the same time used in the genitive form (*see* p. 3 and 4); thus α Crucis (*read*, alpha Crucis) is the brightest star in the constellation Crux; and β Crucis (*read*, beta Crucis) is the next in order; similarly 15 Argûs (Navis) is star 15 in the constellation of the ship Argo.

The Greek Alphabet is here appended for the use of the student: he should make himself familiar with every letter, but especially the first column of letters:—

SIGNS.	NAME.	ENGLISH EQUIVALENT.	SIGNS.	NAME.	ENGLISH EQUIVALENT.
α	alpha	a	ν	nu	n
β	beta	b	ξ	xi or ksi	x
γ	gamma	g	o	omicron	o (short)
δ	delta	d	π	pi	p
ϵ	epsilon	e (short)	ρ	rho	r
ζ	zeta	z	σ	sigma	s
η	eta	e (long)	τ	tau	t
θ	theta	th	υ	upsilon	u
ι	iota	i	ϕ	phi	ph
κ	kappa	k	χ	chi or khi	ch or kh
λ	lambda	l	ψ	psi	ps
μ	mu	m	ω	omega	o (long)

The old specific names of the stars are only retained where common usage and poetry have rendered their retention necessary; thus α Tauri continues to be better known as Aldebaran, while Sirius still seems more familiar than α Canis Majoris, and Arcturus than α Boötis.

* Argelander has shown that Bayer was often guided in the choice of letters by the direction and shape of the constellation, and that alphabetical order does not necessarily indicate relative brightness.

The following is an *Alphabetical List of the principal Stars to which proper Names have been assigned:—*

Achernar = α Eridani
Acubens = α^2 Cancri
Adara = ε Canis Maj.
Albireo = β Cygni
Alchiba = α Corvi
Alcyone (Pleiad) = η Tauri
Aldebaran = α Tauri
Alderamin = α Cephei
Algeiba = γ Leonis
Algenib = α Persei
Algenib = γ Pegasi
Algol = { β Persei, or β Medusæ
Algoreb = δ Corvi
Alhena = γ Geminorum
Alioth = ε Ursæ Maj.
Alioth = α Aurigæ
Alkaid = η Ursæ Maj.
Alkatrops = β Boötis
Alkes = α Crateris
Almach or Alamak = γ Andromedæ
Alnilam = ε Orionis
Alphacca or Alpheta = α Coronæ Borealis
Alphard = α Hydræ
Alpherat = α Andromedæ
Alphirk = β Cephei
Alruccabah = α Ursæ Min.
Alshain = β Aquilæ
Altair = α Aquilæ
Alwaid = β Draconis
Antares = α Scorpii
Apollo = α^2 Geminorum
Arcturus = α Boötis
Arided = α Cygni
Arneb = α Leporis
Azelfafage = π^1 Cygni
Baten Kaitos = ζ Ceti
Bellatrix = γ Orionis
Benetnasch = η Ursæ Maj.
Betelgeux or Betelgeuse = α Orionis
Canopus = α Argûs
Capella = α Aurigæ
Castor = α^2 Geminorum
Chaph = β Cassiopeiæ
Cebalrai = β Ophiuchi
Cor Caroli = 12 Canum Venaticorum
Cor Hydræ = α Hydræ
Cor Leonis = α Leonis
Cor Scorpii = α Scorpii
Cursa = β Eridani
Deneb = β Leonis
Deneb Adige = α Cygni
Deneb Aleet = β Leonis
Deneb Algiedi = δ Capricorni
Deneb Kaitos = β Ceti
Denebola = β Leonis
Diphda = β Ceti
Dubhe = α Ursæ Maj.
Enif = ε Pegasi
Errai = γ Cephei
Etanin = γ Draconis
Fomalhaut = α Piscis Australis
Gemma = α Coronæ Borealis
Gomeisa = β Canis Min.
Hamel = α Arietis
Hercules = β Geminorum
Homan = ζ Pegasi
Izar = ε Boötis
Jed = δ Ophiuchi
Kaus Australis = ε Sagittarii
Kochab = β Ursæ Min.
Korneforos = β Herculis
Lesath = λ Scorpii
Maia Placidus = β Argûs
Markab = α Pegasi
Markab = ζ Argûs
Mebsuta = ε Geminorum
Megrez = γ Ursæ Maj.
Menkalinan = β Aurigæ
Menkar = α Ceti
Merak = β Ursæ Maj.
Mesartim = γ Arietis
Mintaka = δ Orionis
Mira = ο Ceti
Mirach = β Andromedæ
Mirac = ε Boötis
Mirfak = α Persei
Mirzam = β Canis Maj.
Mizar = ζ Ursæ Maj.
Mizar = ε Boötis
Mizar = β Andromedæ
Muphrid = η Boötis
Nath = β Tauri
Nath = γ Aurigæ
Nekkar = β Boötis
Okda = α^2 Piscium
Phact = α Columbæ
Pheeda = δ Ursæ Maj.
Polaris = α Ursæ Min.
Pollux = β Geminorum
Procyon = α Canis Min.
Ras Algethi = α Herculis
Ras Alhague = α Ophiuchi
Rastaban = β Draconis
Regulus = α Leonis
Rigel = β Orionis
Rutilicus = β Herculis
Sadalmelik = α Aquarii
Sadalsund = β Aquarii
Scheat = β Pegasi
Scheat or Sheat = δ Aquarii
Schedir = α Cassiopeiæ
Secunda Giedi = α^2 Capricorni
Seginus = γ Boötis
Sheliak = β Lyræ
Sheratan = β Arietis
Sirius = α Canis Maj.
Sirrah = α Andromedæ
Sothis = α Canis Maj.
Spica, or Spica Aximech = α Virginis
Suhel = α Argûs
Sulaphat = γ Lyræ
Talitha = ι Ursæ Maj.
Tarazed = γ Aquilæ
Thuban = α Draconis
Unuk, or Unukalhai = α Serpentis
Vega = α Lyræ
Vindemiatrix = ε Virginis
Wesat = δ Geminorum
Zavijava = β Virginis
Zaurac = γ Eridani
Zosma = δ Leonis
Zuben el Chamali = α Libræ
Zuben el Genubi = β Libræ
Zuben el Gubi = 20 Libræ
Zuben Hakrabi = γ Libræ

Stars—their Magnitude or Brightness.— The term magnitude, as regards the fixed stars, implies brilliancy, and not size. A few stars of very conspicuous brightness are classed as of the first (1) magnitude; of these only eleven are given in the Nautical Almanac. Stars of slightly inferior brilliancy are said to be of the first-second (1.2) or second-first (2.1) magnitude, according as they approximate more nearly to those of the first or second magnitude. Then come successively stars of the second (2), third (3), fourth (4), and fifth (5) magnitudes, with their subdivisions, as (2.3), (3.2), (3.4), (4.3), &c. The lowest class visible to the naked eye consists of stars varying from the fifth to sixth magnitudes, though good eyes, on clear nights, may probably distinguish some of still less brilliancy, but in this case some uncertainty is occasioned by the difference of estimation caused by organic differences in individual observers. Stars of inferior brilliancy are termed telescopic.

The distribution of the Fixed Stars, in descending magnitudes down to the *ninth*, is given by Argelander approximately as follows:—

1st	2nd	3rd	4th	5th
20	65	190	425	1,100

6th	7th	8th	9th
3,200	13,000	40,000	142,000

Of these the total number that can be distinguished by the naked eye, on the clearest night, does not exceed 3,000 to 4,000.

The following is the order of the stars in brilliancy, superior to the second magnitude, arranged without regard to hemisphere, commencing with Sirius, the brightest star in the heavens:—

Sirius, η Argûs (var), Canopus, α Centauri, Arcturus, Rigel, Capella, α Lyræ, Procyon, α Orionis, α Eridani, Aldebaran, β Centauri, α Crucis, Antares, α Aquilæ, Spica, Fomalhaut, β Crucis, Pollux, Regulus, α Gruis, γ Crucis, ε Orionis, ε Canis Maj., λ Scorpii, α Cygni, Castor, ε Ursæ Maj. (var.), α Ursæ Maj. (var.).

The late Sir J. F. W. Herschel gave, in the "Admiralty Manual of Scientific Enquiry," a List of Fixed Stars in either hemisphere, approximately arranged in order of brightness down to the fourth magnitude, for the purpose of mutual comparision under favourable circumstances of altitude and especially in equatorial and tropical voyages, or land stations, with a view to bringing the nomenclature and scale of magnitudes in the two hemispheres to agreement, and to the improvement of this branch of astronomical knowledge. The comparisons to be made by the naked eye among the stars of both lists not differing much (at the time of observation) in altitude, and in the absence of the moon and twilight, and the results arranged in sequences, beginning with the brightest and ending with the faintest star compared. In each sequence *stars of the two lists should alternate whenever circumstances will allow.*

NORTHERN STARS.

(1)
Arcturus
Capella
α Lyræ
Procyon
α Orionis
Aldebaran
α Aquilæ

(2)
Pollux
Regulus
α Cygni
Castor
ε Ursæ Maj.
α Ursæ Maj.
α Persei
β Tauri
γ Orionis
Polaris
γ Leonis
ζ Ursæ Maj.
α Arietis
β Andromedæ
β Aurigæ
γ Andromedæ

(3)
γ Cassiopeiæ
α Andromedæ
α Cassiopeiæ
γ Geminorum
β Leonis
γ Draconis
α Ophiuchi
β Cassiopeiæ
γ Cygni

α Pegasi
β Pegasi
ε Pegasi
α Coronæ
γ Ursæ Maj.
β Ursæ Maj.
ε Bootis
ε Cygni
α Cephei
α Serpentis
δ Leonis
η Bootis
γ Aquilæ
δ Cassiopeiæ
η Draconis
β Draconis
β Arietis
γ Pegasi
ε Virginis ?
θ Aurigæ
β Herculis
Cor Caroli
β Ophiuchi
δ Cygni
ε Persei
η Tauri
ζ Persei
ζ Herculis
κ Aurigæ
γ Ursæ Min.
η Pegasi
ζ Aquilæ
β Cygni
γ Persei
β Trianguli
δ Persei
ε Aurigæ
α Lyncis

ζ Draconis
π Herculis
β Canis Min. ?
ζ Tauri
δ Draconis
μ Geminorum
γ Bootis
ε Geminorum
δ Herculis
δ Geminorum
π^1 Orionis
β Cephei
θ Ursæ Maj.
ι Ursæ Maj.
η Aurigæ
γ Lyræ
η Geminorum
γ Cephei
κ Ursæ Maj.
ε Cassiopeiæ
θ Aquilæ

(4)
δ Andromedæ
η Herculis
ζ Pegasi
ε Tauri
ζ Cygni
α Trianguli
ζ Aurigæ
λ Aquilæ
μ Herculis
ι Draconis
μ Pegasi
χ Draconis
η Cassiopeiæ
θ Pegasi
ζ Cassiopeiæ

δ Aquilæ
μ Herculis
ξ Geminorum
κ Geminorum
ζ Cephei
η Cephei
ο Ursæ Maj. ?
λ Geminorum
θ Geminorum
ο Andromedæ
β Delphini
ζ Geminorum
α Delphini
41 Arietis
ι Geminorum
λ Tauri
ο Tauri
ξ Tauri
η Piscium
ι Herculis
δ Bootis
γ Trianguli
α Draconis
γ Tauri
γ Arietis
τ Cygni
ι Cephei
ξ Herculis
ο Herculis
ρ Cygni
ι Pegasi
ξ Pegasi
δ Aurigæ
γ Sagittæ
γ Ophiuchi
φ Draconis
γ Delphini
α Piscium

SOUTHERN STARS.

(1)
Sirius
Canopus
α Centauri
Rigel
α Eridani
β Centauri
α Crucis
Antares
Spica

(2)
Fomalhaut
β Crucis
α Gruis
γ Crucis
ε Orionis
ε Canis Maj.
λ Scorpii
ζ Orionis
β Argûs
γ Argûs
ε Argûs
α TrianguliAust.
ε Sagittarii
θ Scorpii
α Hydræ
δ Canis Maj.
α Pavonis
β Gruis
σ Sagittarii
δ Argûs
β Ceti
λ Argûs

(3)
θ Centauri
β Canis Maj.
κ Orionis
δ Orionis
γ Centauri
ε Scorpii
ζ Argûs
α Phœnicis
ι Argûs
α Lupi
ε Centauri
η Canis Maj.
β Aquarii
δ Scorpii
η Ophiuchi
γ Corvi
η Centauri
κ Argûs
β Corvi
β Scorpii
ζ Centauri
ζ Ophiuchi
α Aquarii
π Argûs
δ Centauri
α Leporis
δ Ophiuchi
ζ Sagittarii
π Ophiuchi
β Libræ
γ Virginis
μ Argûs
δ Sagittarii

α Libræ
λ Sagittari
β Lupi
α Columbæ
ι Centauri
δ Capricorni
δ Corvi
β Eridani
θ Argûs
β Hydri
ε Corvi
β Aræ
α Toucani
β Capricorni
ρ Argûs
π Scorpii
β Leporis
γ Lupi
υ Scorpii
ι Orionis
α Aræ
π Sagittarii
α Muscæ
α Hydri
τ Scorpii
ζ Hydræ
γ Hydræ
β TrianguliAust.
σ Scorpii
τ Argûs

(4)
γ Triang. Aust.
η Serpentis

ι Scorpii
υ Argûs
λ Crucis
γ Sagittarii
ν Hydræ
κ Centauri
N Velorum
β Columbæ
ζ Canis Maj.
γ Gruis
α Indi
β Muscæ
λ Centauri
γ Tubi
γ Hydri
ω Argûs
ε Hydræ
θ Eridani
ν Argûs
ξ Argûs
o^2 Canis Maj.
π Hydræ
β Tubi
α Pictoris
φ Sagittarii
α Circini
σ Argûs
α Doradûs
β Phœnicis
δ Aquarii
ζ Scorpii

VARIABLE STARS.—Such stars as *change in brilliancy* (without reference to colour) slowly, regularly, and within certain periods are called *variable stars*. Argelander gives a catalogue of 24 stars of this character, the periods of which are tolerably well known, and it is assumed that there are as many more whose periods have not been ascertained. The "Admiralty Manual of Scientific Enquiry" selects the following as most worthy of observation.

A List of the most conspicuous Variable or Periodic Stars of which observations would be desirable, with their periods of Variation (so far as known) and changes of magnitude.* By Sir J. F. W. Herschel.

Star.	Period. D.	H.	M.	Change of Magnitude.		
β Persei	2	20	48	2	to	4
λ Tauri	4	...	...	3·4	to	4
δ Cephei	5	8	37	3·4	to	5
β Lyræ	6	9	...	3	to	4·5
η Aquilæ	7	4	15	3·4	to	4·5
ζ Geminorum	10	3	35	4·3	to	4·5
α Herculis	60	6	...	3	to	4
ε Aurigæ	19 months ...			...		
ο Ceti	334 days ...			2	to	...
υ Hydræ	494 „ ...			4	to	10
κ Sagittarii	Many years ...			3	to	6
η Argûs	Irregular ...			1	to	4
β Ursæ Minoris... ...	Unknown ...			2	to	2·3
α & η Ursæ Majoris ...	Ditto... ...			1·2	to	2

The phenomenon of variability was first observed in *o* Ceti, hence called *Mira* on account of its wonderful change of light. The periodicity of the change was already recognised in the second half of the 17th century, and Bouillard determined the duration of the period at 333 days; it was also found at the same time that this duration was sometimes longer and sometimes shorter, as well as that the light of the star, when at the greatest, was sometimes brighter and sometimes fainter. This has since been perfectly confirmed. Whether the star ever becomes quite invisible has not yet been decided; but it is certain that for a long time it is merely telescopic, and fainter than the 10th magnitude; most of the observations, however, commence only when, being of the 6th magnitude, it begins to show itself to the naked eye. From that moment the star increases in brightness, at first rapidly, then more slowly, and afterwards more rapidly. On the mean, the time occupied by the increase of light, from the 6th magnitude upwards, is 50 days, and by the decrease of light, down to the same degree of brightness, 69 days; so that the star is visible to the naked eye for an interval of about four months. This is, however, only the mean duration of the star's visibility, which has sometimes been augmented to five, and sometimes diminished to only three months. So, also, the relative duration of the increase and decrease of light is subject to great fluctuations, the former being sometimes slower than the latter, as in 1840, when the star took 62 days to arrive at its greatest brightness, and in 49 days decreased from thence to invisibility to the naked eye. Sometimes, at the time of its greatest brightness, the light of the star scarcely undergoes any sensible change in the course of an entire month: at other times an alteration is distinctly perceptible at the end of a few days. Sometimes, after the star has decreased in brightness for some weeks, a suspension of change for several days ensues, or at least the decrease becomes scarcely sensible. The star also shows great differences of maximum brightness: for example, in November, 1779, it was only a little inferior to Aldebaran, and it has not infrequently been brighter than

* Much has been done lately by astronomers in the observation of known periodic stars and the detection of new ones. A well-compiled catalogue of 121 stars, in the northern heavens, now known to be variable, will be found in *Chambers' Descriptive Astronomy* (Edition of 1867).

stars of the 2nd magnitude; whilst at other times it has not even attained the 4th magnitude; its mean brightness is that of a star of the 3rd magnitude. The duration of the period has been almost even more irregular: in the mean it is 331 days 20 hours, but its fluctuations are as great as a month; for the shortest time which has been known to elapse from one maximum to the next was only 306, and the longest was 367 days.

The variability of *Algol* (β Persei) was first remarked in 1667: it does not increase and decrease in brightness gradually, as do most of the other variable stars, but for two days thirteen hours shines constantly with the same brightness (mag. 2·3), and only shows in less degree of light for between 7 and 8 hours, in the course of which it descends to the 4th magnitude. The decrease and increase of brightness are not quite regular, but, proceeding more rapidly near the minimum, enables the moment of least brightness to be determined to within 10 or 15 minutes. It is remarkable that, after increasing in light for the space of an hour, it remains for about the same time at almost exactly the same degree of brightness, after which it again begins to increase sensibly.

Not less remarkable are the oscillations of increase and decrease in brilliancy in η Argûs, in the great and magnificent constellation of the Ship, which is the glory of the southern heavens. Halley, in 1677, found it of the 4th magnitude, and in 1751 Lacaille saw it of the 2nd magnitude; in 1811-1815 it had returned to the 4th magnitude, but from 1822—1826 it was again seen of the 2nd magnitude, and in 1827 it had attained the 1st magnitude, and quite equal to α Crucis; again for some subsequent years it returned to the 2nd magnitude. Sir John Herschel, at the Cape of Good Hope in 1834-1837, estimated it as between the 2nd and 1st magnitude, but in December, 1837, he was astonished at finding the star increased to such an intensity of light as almost to equal the brightness of α Centauri, and to surpass that of all the other stars of the first magnitude, except Canopus and Sirius: the maximum of brightness was attained in January, 1838: it became fainter than Arcturus, but still surpassed Aldebaran in April, 1838: it went on decreasing until March, 1843, always continuing, however, a star of the 1st magnitude; but in April of the same year its brilliancy began to increase again to such a degree that, from observations at Calcutta and from those of Maclear to the Cape, it was pronounced to be brighter than Canopus, and even almost equal to Sirius.

New Temporary Stars.—This is a class of stars of which little is known at present beyond the fact that they have shown themselves suddenly, have shone with varying brilliancy, and, after a greater or less interval of time, have vanished. If the Chinese records can be trusted, stars of this character have been chronicled as early as 134 years before our Era; but from that date to the present their number has been limited. Of three of these stars, however, eye-witnesses have given a good account.

Tycho Brahe, in November, 1572, (thirty-seven years before the invention of the telescope) discovered, in the constellation Cassiopeia, a radiant fixed star of a magnitude never before seen, and which, in the course of its visibility, underwent an alteration of colour as well as of light. It exceeded in brilliancy Sirius, Vega, and Jupiter, and could only be paralleled to Venus, as seen when nearest the earth: a keen sight could then distinguish the star in the day, and even at noon: at this period its light, during two months, was white. In the spring of 1573, Tycho Brahe compared it to Mars, and next to the star Betelgeuse in Orion, but most nearly of the red colour of Aldebaran: in May the whiteness returned: in July and August its magnitude was of the third order, and in October and November of the fourth, subsequently diminishing to the fifth and sixth: in January, 1574, while of the 5th magnitude, and of a dull white colour, the degree of scintillation was strikingly great in proportion to its feeble light; and in March, 1574, after shining for seventeen months, it disappeared altogether, leaving no trace visible to the naked eye. It has been conjectured that if this is the same star that appeared in or near the constellation Cassiopeia in 945, and again in 1264, its re-appearance will be due shortly before or after 1880; and should it so appear, it will be a variable star of long period.

The next most remarkable star of this character is the one that appeared in Ophiucus in 1604, and seen by Kepler: it was of the 1st magnitude, brighter than Jupiter and Saturn, but inferior to Venus, and not visible in the day; its scintillation was, however, greater than that of the star in Cassiopeia, and excited great astonishment.

The latest star of this character is the one which was observed in 1866 in the constellation Corona Borealis. For some years it had been known as a star of the 9th magnitude. In May of that year it suddenly shone out with great brilliancy; and by the 12th of the month it appeared as of the 2nd magnitude; on the 14th it had decreased to the 3rd magnitude; and subsequently, day by day, it declined in brightness until it again appeared as a telescopic star. Now, in this case a very remarkable history was developed. The spectroscope, which has already thrown much light on the physical constitution of the sun and many of the fixed stars, being happily applied to the star in question by Mr. Huggins and Dr. Miller, it was ascertained that the brilliancy originated in incandescent gasses, one of the gasses being hydrogen; in fact, "the sudden outburst of the star and its rapid decline in brightness from the 2nd to the 8th magnitude in twelve days, suggested the startling speculation that the star became suddenly wrapped in the flames of burning hydrogen."

Double, Triple, and Multiple Stars.—Not a few of the stars which, to the naked eye, appear as single stars, are in reality *double*, *triple*, and even still more numerous—in which case they are called *multiple* stars; sometimes there are *double-doubles:* and these double combinations are not what might be expected from mere chance, or *optical* conjunction—that is from the occurrence of one star nearly in the same visual line with another, but a real *physical* conjunction, being connected by mutual dependence or reciprocal attraction, and forming a particular system of their own.

The existence of orbital motion among these remarkable groups is established beyond all doubt, and the periods of revolution in many cases approximately fixed, as follows—

ζ Herculis	in 30 years	γ Coronæ Bor.	in 100 years
η Coronæ Bor.	43 „	γ Virginis	182 „
ζ Cancri	60 „	δ Cygni	178 „
ξ Ursæ Maj	61 „	β Cygni	500 „
p Ophinchi	74 „	σ Coronæ Bor.	608 „
α Centauri	76 „	Castor	400 to 500 „
ω Leonis	82 „	γ Leonis	1200 „

Of the double-double system in Lyra (ε), the pair farthest apart complete a revolution in 2,000 years, the pair nearest each other in about half that time, and the two pairs round their common centre in something under a million years ; similarly, a complete revolution of Mizar (ζ Ursæ Maj.), Alcor, and the small star near them cannot take place in less than 180,000 of our years ; a complete cycle, therefore, of such a physically-connected group as the Pleiades must be a wholly inconceivable period.

Of the thousands of known double stars, in some cases both are of nearly the same magnitude ; in other cases their magnitudes differ widely ; while in not a few instances it is conjectured that the companion (from the very irregular proper motion of the visible star) must be an opaque orb of immense dimensions.

Not the least remarkable peculiarity in the double and multiple stars is their contrasted and sometimes their complimentary colouring. Though in many instances both stars are of similar hue ; in others, especially when they differ in magnitude, a white star may have a red companion, and there are combinations of green and reddish-yellow, of blue and yellow, &c. Among the multiple star-groups Sir John Herschel described one system in the Southern Cross as comparable "to a superb piece of fancy jewellery," and Humboldt remarks that if these different coloured suns are surrounded by planets invisible to us, such planets must be variously illuminated, having their white and blue, or their red and green days.

Again, when we take into consideration the immense distance of the individual stars of the double system, it appears utterly astounding that to the naked eye they should appear but as single stars, and it bespeaks the *enormous distance at which they are placed from our system.* From observations of the double star 61 Cygni, the individuals composing it cannot be less than 4,000,000,000 (four thousand million) miles apart : and the two stars of α Centauri are 1,200,000,000 (one thousand two hundred million) miles apart.

Colour and Constitution of the Stars.—Mention has already been made of the variety of hues or colours of the multiple star-groups : but the single fixed stars have also their peculiar colours : thus, Aldebaran and Antares are undoubtedly *red ;* Arcturus is *yellow ;* again, some are blue, others green or white : but more extraordinary still, in the lapse of ages they may *change colour*, for, to the Grecian astronomers Sirius was undoubtedly red, whereas now it is white or greenish. Such alteration bespeaks change in the physical constitution of these distant suns. Now, from the application of the spectrum to chemical analysis, we are able to distinguish the components of bodies or gases, in whatever state they may be : similarly, on turning it to the sun's photosphere, it is possible to distinguish the elements of which that is composed. This much, then, we know for a certainty, that that photosphere consists of many of the terrestrial elements in a highly heated state, so heated, in fact, that we cannot conceive of its heat. Applying this knowledge to the examination of the fixed stars, we learn that many of them are like our sun, and that they consist of elements similar to those we know of, and especially of the most abundant and inflammable substances. Such are Sirius, Pollux, and Vega ; the spectra of other stars, on the contrary, give signs which at present are wholly inexplicable, and hence they appear to have in them substances of which at present we know nothing.

Parallax and Distance of the Fixed Stars.—The parallactic angle (or horizontal parallax, as it is termed), and the earth's radius are the two elements required for the determination of the distances of the bodies of the solar system ; but these are finite or measurable distances compared with the distance of any of the fixed stars, and in the admeasurement of the latter the earth's radius is so insignificant a quantity that it utterly fails for the purpose required. "Nevertheless the distance of the stars is a subject which has naturally engaged the close attention of astronomers, ancient and modern ; but all their efforts to arrive at anything like a satisfactory conclusion have failed until within a very recent period. The stars appear in precisely the same positions from whatever part of the earth they are viewed, but with the hope of detecting some change of place by which to judge of their separation from us, they have been observed at points as widely distant from each other as we are able to command, viz., from opposite parts of the earth's annual orbit. With this base-line of 190,000,000 of miles, there is the most favourable chance of detecting the parallax of a star, provided the instruments employed are sufficiently accurate.

"An annual parallax of *one second* of arc would indicate a distance of about 206,000 times the radius of the earth's orbit, that is, of 206,000 times 95,000,000 of miles. In only one instance has a parallax closely approaching this amount been discovered ; and this is in the case of the star α Centauri, which is never visible in England. It is found that the semi-diameter of the earth's orbit would subtend at the star an angle of $\frac{97}{100}$ths of a second, whence it follows that the distance must be 211,000 times the distance of the sun from the earth, or *twenty billions* of miles. The late Professor Henderson, Astronomer Royal at Edinburgh, and formerly at the Cape of Good Hope, has the merit of having first detected the parallax of α Centauri.

"This distance is so enormous that the mind is hardly able to appreciate it ; light, with its astounding velocity of 191,500 miles per second, furnishes the only unit by which it can be measured and brought within small numbers. Suppose a ray to leave this star, travelling through space at the above prodigious rate, it would not reach the earth until after

the expiration of 1218 days, or 3⅓ years. We do not see the star as it actually is, but it shines with the light emitted 3⅓ years ago. Hence if it were obliterated from the heavens, we should continue to see it for more than three years after its destruction.

"Shortly before Professor Henderson's announcement appeared respecting α Centauri, the great astronomer Bessel, of Konigsberg, had published the results of his observations upon a star of the sixth magnitude, numbered 61 in Cygnus, from which it was inferred to have a parallax of $\frac{3}{10}$ths of a second—a conclusion which is supported by the subsequent researches of Professor Peters at the Imperial Observatory of Pulkowa, Russia, and those of our countryman the late Mr. Johnson, Director of the Radcliffe Observatory, Oxford. Other determinations assign a somewhat larger parallax (0″·5); but with the smaller value of Bessel it would appear that the distance of the star must be 550,000 times that which separates the earth from the sun, or 52 billions of miles—a space which light would not traverse in less than 8⅔ years.

"Sirius, the brightest star in the heavens, shows a parallactic displacement of a quarter of a second, which indicates a distance greater than that of 61 Cygni, a star of the sixth magnitude only. Vega in Lyra is supposed to have a parallax of about the same amount. In the present state of our knowledge, it would appear that the *brightest* stars are not always the *nearest* to the solar system.

"It has been considered probable, from recondite investigations, that the average distance of a star of the *first* magnitude from the earth is 986,000 radii of our annual orbit, a distance which light would require 15½ years to traverse; and further, that the average distance of a star of the *sixth* magnitude (the smallest distinctly seen without a telescope) is 7,600,000 times the same unit—to traverse which, light, with its prodigious velocity, would occupy more than 120 years. If, then, the distances of the majority of stars visible to the naked eye are so enormously great, how are we to estimate our distance from those minute points of light discernable only in powerful telescopes? The conclusion is forced upon us that we do not see them as they appeared within a few years, or even during the lifetime of man, but with the rays which proceeded from them several thousand of years ago! What an idea does this consideration give us of the immensity of the stellar universe!"—J. R. Hind's *Introduction to Astronomy.*

Proper Motions of the Stars.—The *apparent motion* of the fixed stars, which depends on the rotation of the earth on its axis, and on its revolution round the sun, are known to every observer: again, the changes in the positions of the stars due to aberration and nutation, which are merely apparent movements, can be readily calculated for every star. The effects of precession can also be determined with equal facility.

"It is found by observation, however, that most stars exhibit a slow motion in the heavens which cannot be thus accounted for; after due allowance has been made for precession, aberration, and nutation, there still remain very appreciable changes of position. These are not such periodical motions to and fro as would be produced by parallax; on the contrary, they are uniformly progressive from year to year.

"There are two ways in which such movements may be explained in the case of an *individual star*. Either the star itself may be supposed to have a real motion through space to the observed amount, or the sun, the earth, and all the other planets may have a similar real motion in a contrary direction to that of the star's apparent one. On extending the inquiry to a greater number of stars, it appears beyond doubt that both causes must be in existence, certain stars having a really independent motion in the heavens, which, to distinguish it from merely apparent displacements, is termed the *proper motion*, while the solar system itself *travels through space.*

"Although the observations of modern astronomers show that a great number of stars exhibit proper motions, there are some few that have especially attracted attention from the rapidity with which they appear to be journeying as compared to the rest: 61 Cygni, one of the stars already mentioned as within measurable distance, is moving at the rate of more than five seconds annually; and a star in Ursa Major (known as 1830 of Groombridge's Catalogue and frequently termed Argelander's star) travels at the rate of seven seconds in a year. The parallaxes, and hence the distances of both stars, are presumed to be approximately known; but we are ignorant of the *real directions* of their proper motions in the heavens, and therefore cannot assign the exact velocities at which they are travelling: they may be moving either towards us or from us; and their real change of place in a certain interval being thus foreshortened, the apparent movements would be very much less than the true ones. Still, if we suppose that the real direction of their proper motions is perpendicular to our line of vision, we can attach a velocity to each star, *less* than which the true one *cannot be;* and thus it is computed that 61 Cygni is flying onward through space at the rate of *forty miles in a second*, and the star in Ursa Major at even greater speed."—J. R. Hind

Sir W. Herschel suspected that the Sun, which is a fixed star, had a proper motion in space, and the subject attracted considerable attention. It has since been approximately determined that the *direction* of this movement of the sun is towards a point in the constellation Hercules, in R.A. 17¼ h., Dec. 35° N., at the *rate* of 4 miles in a second; and the whole planetary system accompanies its central orb towards that point. The spectrum has given considerable assistance towards the investigation of this important subject, and by its aid it has been found that Sirius is moving through space at the rate of 30 miles in a second, while Arcturus is hurrying onward at a rate of not less than 54 miles in a second. Thus, though the stars are apparently at rest, they are really moving through space with enormous velocities, but owing to their equally enormous distance from each other, it takes ages to produce any change in the relative aspect of the star-groups in the heavens.

The Milky Way or Galaxy is that belt of pale light stretching across the heavens, which, when examined by the

aid of the telescope, is found to consist of multitudes of stars, closely crowded together. Its position and aspect have thus been described by Humboldt:—

"In order to afford a general view of the course and direction of the Milky Way, together with its subordinate branches, I subjoin a brief and compressed account of its parts, following their order of Right Ascension. Passing through γ and ϵ Cassiopeiæ, the Milky Way sends out to the southward, towards ϵ Persei, a branch, which loses itself near the Pleiades and Hyades. The main stream, which is here very faint, passes over the three remarkable stars called the Hædi, in Auriga, between the feet of Gemini and the horns of Taurus, where it intersects the ecliptic nearly at the summer solstice, and thence over the club of Orion, cutting the equinoctial, at 6h. 54m. R.A., in the neck of Monoceros: from this place it increases considerably in brightness. At the after-part of the Ship a branch detaches itself towards the south, proceeding as far as γ Argûs, where it breaks off suddenly. The main course continues to 33° South Declination, where having opened out into a fan-like shape 20° wide, it breaks off; so that, in the line between γ and λ Argûs, there is a wide gap in the Milky Way. After this it resumes its course, at first with a similar expansion in breadth; but near the hind feet of the Centaur it narrows again, and before entering the constellation of the Cross it reaches its narrowest part which is only 3° or 4° wide. Soon afterwards the shining Way spreads out into a bright and broad mass, which includes β Centauri as well as α and β Crucis, and in the middle of which the black pear-shaped Coal-bag or Coal-sack, is situated. It is in this remarkable region, a little below the Coal-sack, that the Milky Way approaches nearest to the South Pole.

"The principal division of the Milky Way, alluded to above, takes place at α Centauri: it is a bifurcation which, according to older views, continues to the constellation of Cygnus. Proceeding from α Centauri, a narrow branch goes northwards towards the constellation Lupus, where it loses itself: then a division shows itself at γ Norma. The northern branch runs into irregular shapes until near the feet of Ophiuchus, where it entirely disappears; the southern branch now becomes the main stream, and passes through the Altar and the tail of the Scorpion to the bow of Sagittarius, where it cuts the Ecliptic in 18h. 24m. R.A. Further on we recognise it still, but in an interrupted patchy form, passing through Aquila, Sagitta, and Vulpecula to Cygnus. Here begins a very irregular district, where between ϵ, α, and γ Cygni there is a broad dark space, which Sir John Herschel compares to the Coal-sack in the Southern Cross, and which forms, as it were, a centre whence three partial streams diverge. One of these, which has most strength of light, may be pursued in, as it were, a retrograde course past β Cygni and s Aquilæ: it does not, however, unite with the branch before spoken of, which goes to the foot of Ophiuchus. There is still a considerable additional piece of the Milky Way, which extends from the head of Cepheus, and, therefore, in the vicinity of Cassiopeia (from which constellation we began our description) to Ursa Minor and the North Pole."

The Magellanic Clouds.—Not very dissimilar from the Milky Way, but in no way connected with it, are those cloudy-looking, oval-shaped masses of light visible in the Southern Hemisphere, which are known as the Magellanic Clouds, and distinguished by astronomers as the Nubecula major and Nubecula minor. They are so remarkable as to have attracted the attention of the earliest voyagers into the southern seas. Humboldt describing them, says:—

"The two Magellanic clouds, of which the larger covers forty-two and the smaller ten square degrees of the celestial vault, produce at first sight, as seen by the naked eye, the same impression as would be made by two detached bright portions of the Milky Way of corresponding dimensions. In strong moonlight the smaller cloud disappears entirely, while the larger one only loses a considerable portion of its light. It is to the arduous exertions of Sir John Herschel at the Cape of Good Hope in 1837 that we owe the first accurate analysis of these wonderful aggregations of the most various elements. He found therein single scattered stars in great number; groups of stars and globular star-clusters; and both regular oval, and irregular-formed nebulæ, more closely crowded than in the nebular zone of Virgo and Coma Berenicis. From the complex character of the nubeculæ, therefore, they ought not to be regarded either (as is too often done) as extraordinarily large nebulæ, or as detached portions of the Milky Way. In the Milky Way, round star-clusters, and more especially oval nebulæ, are extremely rare phenomena, excepting in a small zone situated between the constellation Ara and the tail of Scorpio.

"The Magellanic clouds are neither connected with each other nor with the Milky Way by any perceptible nebulous appearance. The smaller nubecula is situated in what, excepting the vicinity of the star-cluster in Toucani, is a kind of starless desert; the larger Magellanic cloud is in a less scantily furnished part of the celestial vault. The structure and internal arrangement of the larger nubecula are so complicated that masses are found in it in which the general form and character of the entire cloud are exactly repeated. According to Sir John Herschel, nubecula minor is situated between 0h. 28m. and 1h. 15m. R.A., and between 72° and 75° S. Dec.; and nubecula major in 4h. 40m.—6h. 0m. R.A., and 66°—72° S. Dec. Of stars, nebulæ, and clusters, he has given in Right Ascension and Declination no fewer than 919 in the larger, and 244 in the smaller nubecula. In order to distinguish the three classes of objects from each other, I have counted up in the list:—

"In nubecula major, 582 stars, 291 nebulæ, 46 star-clusters.

"In nubecula minor, 200 stars, 37 nebulæ, 7 star-clusters.

"The smaller number of nebulæ in the nubecula minor is striking; their proportion to the nebulæ in nubecula major being as 1:8, while the corresponding ratio of single stars in the two nubeculæ is about as 1:3. These tabulated stars, almost eight hundred in number, are mostly of the 7th and 8th magnitudes, some being between the 9th and 10th. In the midst of the nubecula major there is a nebula noticed as early as by Lacaille, which is without a parallel in any part of the heavens. It hardly occupies $\frac{1}{300}$th of the area of the entire

nubecula, and yet within this space Sir John Herschel has determined the positions of 105 stars from the 14th to the 16th magnitude, which are projected against, or detach themselves from, the altogether unresolved, uniformly-shining, and unchequered nebulous ground.

"Opposite to the Magellanic luminous clouds, and at a greater distance from the Southern Celestial Pole, there revolve around it the black spots or patches which at an early period, at the end of the fifteenth and beginning of the sixteenth centuries, attracted the attention of Portuguese and Spanish navigators. Richaud, like the oldest navigators, speaks of the 'coal-sacks' in the plural; he names two—one in the Cross, and another in Robur Caroli: in other descriptions this last is even divided into two separate spots or patches. During my stay in Peru, I never could make out in a manner satisfactory to myself the 'coal-sacks' in Robur Caroli; and other astronomers have not succeeded, any more than myself, in finding anything which for definiteness of outline or intensity of blackness could be compared to the 'coal-sack' in the Cross. Sir John Herschel thinks that we ought not to speak of a plurality of coal-sacks unless we intend to regard as such every darker portion of the heavens, even though it may present no definite boundary.

"The phenomenon of this class which has been longest known, and which is most striking to the unassisted eye, viz., the dark patch in the Southern Cross, is situated on the eastern side of that constellation, and is pear-shaped, with a length of 8 and a breadth of 5 degrees. There is in this large space one star visible to the naked eye, (between the 6th and the 7th magnitude), and a large number of telescopic stars from the 11th to the 13th magnitudes. A small group of 40 stars occupies nearly the centre of the space. Paucity of stars and contrast with the surrounding brightness have been assigned as the causes of the sensible blackness of the space in question; and since the time of Lacaille this explanation has been generally received. It has been more particularly supported by the results of 'star-gauges and sweeps' taken around the space where the Milky Way appears as if covered by a black cloud. With equal fields of view, the sweeps gave within the coal-sack from 7 to 9 telescopic stars, (never perfect vacuity or blank fields) while around and beyond the borders from 120 to 200 stars were counted. Whilst I remained under the southern tropic, and under the influence of the powerful impression made upon me by the aspect of the celestial canopy towards which my attention was continually drawn, the above explanation, from the effect of contrast, appeared to me, probably erroneously, to be an unsatisfactory one. Sir William Herschel's considerations on the quite starless spaces in Scorpio and Ophiucus, which he terms 'openings in the heavens,' led me to the idea that perhaps in such regions the sidereal strata may be thinner or may even be entirely interrupted; that our optical instruments fail to reach the last strata, and that 'we look as through tubes into the remotest regions of space.'"

Star-Clusters and Nebulæ.—Besides what have been described in connection with the Milky Way and Magellanic Clouds, there are other star-clusters and cloudy spots of irregular shapes in the region of various constellations, just visible to the naked eye, and no more. There are also other clusters and patches wholly invisible to the naked eye, but shown up by the aid of powerful telescopes. On these it is unnecessary to dwell; nor yet is this the place to enter into an elaborate discussion of the nebulæ, which no telescope can resolve, but which the spectrum appears to indicate to be masses of glowing or incandescent gas. These subjects are treated at large in works devoted to physical astronomy.

Summary of Spectrum Analysis of the Heavens.—The investigations of Mr. Huggins have led him to the following conclusions in respect to the star worlds which we nightly see in the heavens:—

"(1.) All the brighter stars have a structure analogous to that of the sun.

"(2.) The stars contain material elements common to the sun and earth.

"(3.) The colours of the stars have their origin in the chemical constitution of the atmosphere which surrounds them.

"(4.) The changes in brightness of some of the variable stars are attended with changes in the lines of absorption of the spectra.

"(5.) The phenomena of the star in Corona Borealis appear to show that, in this object at least, great physical changes are in operation.

"(6.) There exist in the heavens true nebulæ. These objects consist of luminous gas.

"(7.) The material of comets is very similar to the matter of the gaseous nebulæ, and may be identical with it.

"(8.) The bright points of the star-clusters may not be in all cases stars of the same order as the separate bright stars."

Effect of the Precession of the Equinoxes.—"By the precession of the equinoxes the aspect of the starry heavens from every point of the earth's surface is constantly changing. The earlier inhabitants of our high northern latitudes might see magnificent southern constellations rise to their view, which, now long unseen, will not re-appear for thousands of years. In the time of Columbus, the star Canopus was already $1\frac{1}{3}°$ below the horizon at Toledo (lat. 39° 54′): it is now about 1° above the horizon at Cadiz (lat. 36° 32′). For our northern latitudes the stars of the Southern Cross, as well as α and β Centauri, are receding more and more; whilst the Magellanic Clouds are slowly approaching us. Canopus had its greatest northerly approximation during the thousand years which have closed, and is now moving (though, on account of its proximity to the south pole of the ecliptic, with extreme slowness) progressively to the south. The Southern Cross began to be invisible in lat. $52\frac{1}{2}°$ N. about 2900 years before the Christian era. It might previously have reached, in that latitude, an altitude of more than 10°; and when it vanished from the horizon of the countries adjoining the Baltic, the great Pyramid of Cheops had already been standing in Egypt for five centuries. In the time of Claudius Ptolemæus α Crucis (then considered a part of Centaurus) had still an altitude of 6° 10′ at its meridian passage at Alexandria; whilst at the present day it culminates several degrees below the horizon of that place."—Humboldt's *Cosmos*.

CHAPTER II.

THE CONSTELLATIONS AND PRINCIPAL FIXED STARS—THEIR RELATIVE POSITIONS—WITH PRACTICAL DIRECTIONS FOR FINDING THEM.

THE plates which accompany this work give the constellations and stars white on a black ground, and the maps are arranged as follows:—

I. The constellations near the North Pole, including all bright stars circumpolar to latitude 48° N.

II. The constellations and stars in and near the zodiac, or between Declination 45° N. and 45° S., ranging from Right Ascension 0h. to 12h.

III. The constellations and stars in and near the zodiac, or between Declination 45° N. and 45° S., ranging from Right Ascension 12h. to 24h.

IV. The constellations near the South Pole, including all bright stars circumpolar to latitude 48° S.

The best methods of tracing out the stars by their relative positions, are—(1.) by imagining right lines, or rather arcs of circles, to pass through two or more stars, leading to one required; (2.) by forming three or more into some geometrical figure; (3.) by their bearings from each other, when the star from which the bearing is given, is *on the meridian above the pole*; or, (4.) by their angular distances, as seen by an observer on the surface of the earth. In the following directions, occasion will arise for using one or more of these methods, as may appear to suit the purpose of more accurately defining the position of any given star, and to this end it is proposed, in the first place, to describe a few of the most remarkable and easily distinguished constellations and stars, and by their aid to run rapidly through the list of the principal stars in both hemispheres; subsequently dwelling at greater length on all, and giving such descriptions as shall facilitate the recognition, by the merest novice, of any particular star or group required.

The purpose we have in view will be fully attained by noticing at first and at some length the Great Bear, the Little Bear, Draco, Orion, and the Southern Cross.

URSA MAJOR AND URSA MINOR.

The **Great Bear**, the **Little Bear**, and **Bootes** are three constellations very frequently mentioned in the writings of the Ancients. Among the Greeks the general name of the two Bears was **Arctos**, whence the term Arctic Regions for the circumpolar area: both were also sometimes designated as the *Waggon* or *Wain*. The constellation Boötes (the Herdsman or Ploughman) at a later date became **Arctophylax**, or the *Bear-Watcher*. All these constellations are connected in mythology with the Arcadian nymph Callisto, the daughter of Lycaon. Metamorphosed by Zeus (Jupiter) upon the earth into a she-bear, Callisto was pursued by her son Arcas in the chase, and when he was on the point of killing her, Zeus placed them both among the stars, Callisto becoming the Great Bear, and Arcas the Little Bear, or perhaps Boötes.

Homer mentions these constellations in the Odessey, as follows:—"Nor did sleep fall upon his eyelids as he watched the Pleiades, and the late-setting Boötes, and the Bear, which also is commonly called the Wain, which revolves in that part of the heavens, and watches Orion, and alone is never bathed in the ocean."

The old Latin name for the Great Bear was **Septem Triones**, or the *Seven Ploughing Oxen*.

URSA MAJOR or the **Great Bear** (*see* Map I.)—In this constellation, which is one of the most remarkable and conspicuous in the Northern Hemisphere, there are *seven* principal stars, denoted by the Greek letters α, β, γ, δ, ϵ, ζ, and η: four of these stars, forming a quadrangular figure, sometimes called the *square* of the Great Bear, constitute the body of the animal; the other three stars, projecting from the *square*, form the tail of the Bear. From the earliest ages these seven stars had attracted the attention of the common people, and they were almost universally known as the *Wain* or *Waggon*; at a later date they were not unfrequently called the *Plough*, from their resemblance to that implement: in England they are also sometimes called *Charles' Wain*, and by the French *le Chariot de David*.

Commencing at the end of the tail of the Great Bear is η Ursæ Majoris, called also Benenasch; about 7° to the westward is ζ or Mizar, with its attendant Alcor,—a double star: and about $4\frac{1}{2}$° still further westward is ϵ or Alioth. Next, about $5\frac{1}{2}$° from Alioth, at the root of the tail, is δ or Pheeda; southward of the latter is γ or Megrez; these form the shorter side of the quadrilateral: about 8° westward of Megrez is β or Merak, to the northward of which (5°) is α Ursæ Majoris, or **Dubhe**.

Alioth and Dubhe are the two brightest stars in the constellation, and the latter name signifies in Arabic the "Bear."

Merak and Dubhe (β and α) are commonly called the *Pointers*, because a line drawn from β through α, and extending about 29° in that direction, points *nearly* towards Polaris, or as it is commonly called, the Pole Star, which is not, however, exactly on, though close to, the North Polar point of the heavens, being distant $1\frac{1}{3}$° therefrom: no other equally bright star is in its vicinity.

When the Great Bear is below the Pole, the same line from β through α, and thence through Polaris to twice the distance that the latter is from α, will point out the four stars forming the *square* of Pegasus.

A line from γ passing between α and β Ursæ Majoris leads towards Capella in Auriga.

The prolongation of the curve of the tail of the Great Bear leads to Arcturus in Boötes.

A line from δ through β Ursæ Majoris leads towards Castor and Pollux in Gemini.

A line from η through β Ursæ Majoris leads towards Sirius in the Greater Dog.

A line from δ through γ Ursæ Majoris leads towards Regulus in Leo.

A line from α through γ Ursæ Majoris leads towards Spica in Virgo.

URSA MINOR, or the **Little Bear.**—The principal stars in this constellation consist of seven, similar in figure to those in Ursa Major, but the figure is smaller, and the stars fainter, with the exception of Polaris; it may also be observed that these stars are always in a reversed position with respect to those in the Great Bear, and consequently the tails of the two Bears lie in opposite directions. (*See* Map I.)

Polaris, or α Ursæ Minoris is at the end of the tail, while β and γ form the further side of the quadrilateral figure.

The use of Polaris in navigation is well known and is very ancient; it was also called the *Lode Star*, *i.e.* the guiding star; but at an earlier date it was called *Cynosura*, or the *Dog's Tail*, when the constellation was figured as a dog. It has already been explained how the *Pointers* (β and α) of the Great Bear lead to Polaris. The Arabic name of the star is *Al Ruccabah*.

To the early Spanish navigators the two stars β and γ Ursæ Minoris indicated by their position, before watches and chronometers were in use, the hours of the night, hence they were called the *Guards* from *Guardar, to watch*. It may also be observed that the star β was nearer to the pole 2,000 years ago than Polaris—it was, in fact, the North or Pole Star of the Arabian astronomers, and on that account called *Kochab*.

Polaris is now about $1\frac{1}{3}°$ distant from the pole of the heavens, but is still approaching that point, and will continue to do so for the next hundred years (or rather more); it will then be within half a degree of the pole, after which, owing to the precession of the equinoxes, it will commence its recession, and eventually give place to another star, Vega in Lyra, the pole star of the future, as Kochab and α Draconis have been in the past. Vega in 12,000 years, will be within 5° of the pole.

The North Pole of the Heavens is on the perpendicular line drawn from Polaris to meet a line passing through the *guards* (γ and β Ursæ Minoris), about $1\frac{1}{3}°$ from Polaris, in the direction towards the Great Bear. Hence, when the stars δ and ε of the Great Bear are about six hours from the meridian, Polaris will be at its greatest distance from the meridian, and have nearly the same altitude as the pole, that altitude being equal to the latitude of the observer. When, however, Polaris is on the meridian, it must either be above or below the pole, and its altitude accordingly in excess or defect of the latitude of the observer. Tables for correcting the altitude of Polaris, observed at any hour, and reducing it to the meridian altitude, are given in the Nautical Almanac.

The Pole of the Ecliptic is nearly on a line joining Polaris and γ Draconis, about half-way between the Pole of the Heavens and the Dragon's Head.

CASSIOPEIA.—It may also be worth remembering, and aid in tracing out the stars, that Cassiopeia, which is a constellation something like a distorted W or M, is as far from Polaris in one direction as the Great Bear is in the opposite (*see* Map I.): hence, when the Great Bear is on the meridian below the pole Cassiopeia is on the meridian above the pole, and *vice versa*. The stars of this constellation are sufficiently conspicuous, and are frequently called the *Lady in the Chair*.

DRACO—THE DRAGON.

DRACO—the Dragon.—None of the stars of this constellation attain the second magnitude, yet several of them are worthy of notice. The constellation is remarkable for its winding direction, for, commencing northward of Lyra and Hercules, in R.A. 17 h., Dec $51\frac{1}{2}°$ N., it trends towards Cepheus and along the body of the Little Bear, then, curving round between the *Guards* of the latter and the tail of the Great Bear, it terminates near α, the *northern pointer* of the Great Bear: this position of Draco and the circumpolar character of the two Bears are described in the first Georgic of Virgil:—"The enormous Dragon, like a river, glides round with winding flexure, between the two Bears—the Bears that fear to dip in the Ocean." (*See* Map I.)

The principal stars in the constellation are α, β, γ, and η^2 Draconis: the star η^2 (mag. 3.2) is a double one, and is near the middle of the body of the Dragon.

The stars β and γ (respectively of mag. 3.2 and 2.3) are in the head of the Dragon, which lies nearly in the line of the *guards* of the Little Bear, *i.e.*, in the direction *from β through γ* Ursæ Minoris; they also lie rather more than half-way between the square of Ursa Minor and the star Vega in Lyra, nearer the latter, where of four stars forming a small lozenge-shaped figure, β and γ Draconis are the most conspicuous. As γ Draconis passes nearly vertically over Greenwich, it was on that account chosen by the great astronomer Bradley as the most suitable for his observations, and which led him to the twofold discovery of the Aberration of light and the Nutation of the earth's axis: hence this star is a remarkable one in the history of astronomy.

The star η^2 Draconis is nearly midway between the *guards* of the Little Bear and β Draconis, nearer the former.

The star α Draconis, midway between the *guards* of the Little Bear and the middle star of the tail of the Great Bear, is remarkable as illustrating the effect of the Precession of the Equinoxes. To the ancient Chaldean observers it was the *Pole Star*, and was within a quarter of a degree of the Pole. At the time of the building of the great Egyptian pyramid of Gizeh (in lat. 30° N.), about 4,000 years before our era, it was about $3\frac{1}{2}°$ distant from the Pole, and consequently still the Pole Star: and on this Sir JOHN HERSCHEL, in his *Outlines of Astronomy*, observes:—"It is a remarkable fact, ascertained by the late researches of Colonel Vyse, that of the nine pyramids still existing at Gizeh, six (including all the largest) have the narrow passages by which alone they can be entered (all which open out on the northern faces of their respective pyramids) inclined to the horizon downwards at angles as follows—26° 41′, 25° 55′, 26° 2′, 27°, 27° 12′, 28°; mean of all 26° 47′.

"Of the two pyramids at Abousseir also, which alone exist in a state of sufficient preservation to admit of the inclinations of their entrance passages being determined, one has the angle 27° 5′, the other 26°

"At the bottom of every one of these passages, therefore, the *then* Pole Star must have been visible at its lower culmination, a circumstance which can hardly be supposed to have been unintentional, and was doubtlessly connected (perhaps

superstitiously) with the astronomical observation of that star, of whose proximity to the pole at the epoch of the erection of these wonderful structures, we are thus furnished with a monumental record of the most imperishable nature."

CEPHEUS, one of the ancient constellations, is situated between Draco and Cassiopeia, but its stars are not easily distinguished from those of Draco. However, a line from Dubhe (α Ursæ Maj.) through Polaris, and another from γ Ursæ Majoris through the second star from Polaris (in the Little Bear) will lead to the principal stars in Cepheus, of which Alderamin is the most conspicuous. Like Cassiopeia when the Great Bear is above the pole, Cepheus is below the pole; when the Great Bear is below the pole, Cassiopeia and Cepheus are above it. (*See* Map I.)

Camelopardus and Lynx.—The stars in these two constellations are by no means remarkable: but when the Great Bear is above the pole they are westward of the Great and Little Bears; when the Great Bear is below the pole they are eastward of the same two constellations. (*See* Map I.)

AURIGA, the **Charioteer,** is a beautiful constellation and its two chief stars are nearly on a line extending from δ through α (Dubhe) Ursæ Majoris. The principal star, Capella (α), or the She-goat, is also the Lucida of ancient writers, and of the stars of the northern hemisphere it stands next to Arcturus in brilliancy. Just to the southward (westerly) of Capella lie three small stars, called Hædi, or the Kids. Below (17° to the southward of) Capella and β Aurigæ comes the star marking the tip of the *horn* of Taurus, one of the signs of the Zodiac, the three stars forming an isosceles triangle. (*See* Maps I. and II.)

ORION.

Orion, in the mythology of the ancients, was a handsome giant and hunter, who, living for sometime in the train of Artemis (Diana), became her lover; being killed for his temerity, he was then placed among the stars where he appears as a giant with a girdle, sword, a lion's skin, and a club (*See* Map II). Orion is one of the forty-eight old constellations, and the equinoctial plane passes through it. Being conspicuous in the heavens during the nights of the winter months of the northern hemisphere (passing the meridian between 9h. and 10h. p.m. in January) the ancients regarded it as a constellation of evil omen, bringing with it severe tempests and frequent rain. It is mentioned in the Book of Job, and allusion is continually made to it by Greek and Roman writers.

The three principal stars in the constellation with a much smaller one form a quadrilateral figure, longest in a north and south direction. The north-eastern star is α Orionis (**Betelgeux** or **Ibt-al-Jura,**) and, though variable, is of mag. 1; the north-western star, γ Orionis (**Bellatrix**), is of mag. 2; these are in the shoulders of Orion; nearly midway between them, but somewhat to the northward, are three small stars, forming a triangle, in the head of Orion. The south-western star of the quadrangle, forming Orion's foot, is **Rigel** (β Orionis) of mag. 1; and the south eastern star is κ Orionis, of mag. 3.

Within the quadrangle are three stars (δ, ϵ, ζ) in a line N.W. and S.E., nearly equidistant, and not exceeding mag. 2; these form Orion's *Belt.* To the southward of the Belt, three small stars (η, ι, and κ) of mag. 3 form the *Sword* of Orion. Close to ι Orionis is a cluster of small stars and a remarkable *nebula.*

A line from Betelgeux through the stars in the head of Orion leads to Aldebaran in Taurus.

A line from Rigel through the middle star of Orion's Belt leads towards Castor and Pollux in Gemini.

A line from Betelgeux through Bellatrix will lead towards α (Menkar) Ceti, and Mira (o Ceti).

A line through the stars of Orion's Belt towards the S.E. will lead to Sirius in Canis Major.

THE SOUTHERN CROSS.

The Southern Cross, the most remarkable and conspicuous constellation in the southern hemisphere was considered by Ptolemy as part of the Centaur, hence it does not appear in the list among the ancient constellations. Indeed the distinctive name of **Crux** was first given it by Halley, though the Christian anchorites of Thebais in the fourth century must have seen it; later on, Dante speaks of the "four stars," and Amerigo Vespucci, in his third voyage, of "the four stars never before seen save by the first human pair:" in 1517 the Florentine Andrea Corsali mentions the "wondrous cross, more glorious than all the constellations of the entire heavens;" and in the Spanish settlements of tropical America, the first settlers were accustomed to infer the hour of the night from the inclined or perpendicular position of the four stars. It does seem strange, therefore, that when the Christian observers and voyagers of the Middle Ages were ever anxious to make out crosses in the heavens, the "four stars" should have remained without a distinctive appellation, as a "Cross," until the days of Halley. (*See* Map IV.)

Of the four stars of the Cross, α^2 is the southernmost, and a double star; γ is the northernmost, β the easternmost, and δ the westernmost, when above the pole: α^2 is of mag. 1; β and γ of mag. 2.

A line from Arcturus through Spica leads to the Southern Cross, and it is on the meridian above the pole at about 7h. p.m. in the southern mid-winter, in June.

A line from γ through α^2 Crucis, prolonged three and a half times their distance apart indicates (approximately) the position of the South Pole.

A line from δ through α^2 Crucis leads to Fomalhaut in the Southern Fish.

A line from δ through β Crucis leads to β and α Centauri.

A line from α^2 through β Crucis leads towards Spica in Virgo.

A line from α^2 through β Centauri leads to Antares in Scorpio.

The constellations in the immediate vicinity of the North Pole being known, and their positions with reference to

each other and the pole being remembered, they form good guides and points of departure whereby the other northern constellations and the principal stars may be readily found. Similarly Orion and the Southern Cross have been selected as guides for finding the positions of the constellations and principal stars within the zodiacal region, and in the southern hemisphere.

GENERAL DIRECTIONS FOR FINDING THE PRINCIPAL STARS.

The *Pleiades* or *Seven Stars* are in the constellation Taurus. Nearly S.E. by E. from the Pleiades, at the distance of 14°, is α Tauri, or **Aldebaran** (1): this star has a reddish appearance, and is very easily known.

Nearly in the same line with the Pleiades and Orion's belt, and about 21½° S.E. of the southern star of the belt, is α CANIS MAJORIS, or **Sirius** (1), the Dog Star: it is the brightest fixed star in the heavens.

About 26° nearly East of Betelgeux, and nearly the same distance N.E. of Sirius, is α CANIS MINORIS, or **Procyon** (1). *Sirius*, *Betelgeux*, and *Procyon* form nearly an equilateral triangle.

A line from *Rigel* through the middle of Orion's belt will point out α Geminorum, or **Castor** (2): 4½° to the S.E. of Castor is β Geminorum, or **Pollux** (2).

At the distance of 38° from *Procyon*, and nearly in a line with it and the southern star in Orion's belt, is α Leonis, or **Regulus** (2); and nearly in the same line, at the distance of 25° E. by N. from *Regulus*, is β Leonis, or **Denebola** (3). About 35° E.N.E. from *Denebola* is α Boötis, or **Arcturus** (1).

About 33° S.S.W. of *Arcturus*, and 35° S.E. of *Denebola*, is α Virginis, or **Spica** (1). *Denebola*, *Arcturus*, and *Spica* form nearly an equilateral triangle, and nearly in the centre of this triangle is ϵ Virginis, or **Vindemiatrix** (3).

Nearly in a line from *Regulus*, through *Spica*, at the distance of 46° from the latter, is α Scorpii, or **Antares** (1): this star has a reddish appearance, like *Aldebaran*.

A little north of a line joining *Spica* and *Antares*, and about 21° from *Spica*, is α Librae, or **Zuben-el-Chamali**, (3); this is a double star. About 9° N.E. of *Zuben-el-Chamali* is β Librae, or **Zuben-el-Genubi** (3).

At the distance of 60° N.E. by E. from *Antares* is α Aquilae, or **Altair** (1); this star may also be known by its being E. by N. from *Spica*, and a little north of a line from *Spica* through *Zuben-el-Genubi*; also by its being situated on the southern border of the Milky Way, considerably distant from any other bright star.

A line from *Altair* through the Dolphin, at the distance of 49° from *Altair*, will point out β Pegasi, or **Scheat** (3): about 14° East of *Scheat* is α Andromedae, or **Alpherat** (3): about 14° South, a little easterly, from *Alpherat* is γ Pegasi, or **Algenib** (3): and about 17° nearly West of *Algenib*, and 13° South of *Scheat*, is α Pegasi or **Markab** (3): *Scheat*, *Alpherat* *Algenib*, and *Markab* form what is generally called the *square* of Pegasus, or the Flying Horse:—*Markab* being in the S.W. corner of the square.

A line from *Scheat*, through *Markab*, being produced to the distance of 45° from the latter star, will point out α Piscis Australis, or **Fomalhaut** (2). *Altair*, *Markab*, and *Fomalhaut* form nearly a right-angled triangle, the right angle being *Markab*.

Nearly in a line joining *Markab* and the *Pleiades*, and about 23° West of the *Pleiades* is α **Arietis** or *Hamel* (2). This star may also be known by being a little to the S.W. of a line from *Betelgeux* through *Aldebaran*, its distance from the latter star being 35°. About 4° S.W.-ward from α is β *Arietis* (3).

About 23½° S.E. by S. from α *Arietis*, and a little north of a line from *Betelgeux*, through *Bellatrix*, at the distance of 36° from the latter star, is α Ceti, or **Menkar** (2). *Menkar* may also be known by being in a line with *Rigel* and *Algenib*, and rather nearer to *Rigel* than to *Algenib*.

A line from *Rigel* to the *Pole Star* will nearly intersect α Aurigæ, or **Capella** (1). This star is 43½° from the *Pole Star*, and 54° from *Rigel*. *Capella* may also be known by its being in a line from *Menkar* through the *Pleiades*, and about 28° to the N.E. of that cluster. About 7½° E. by S. from *Capella* is β Aurigæ (2).

Nearly in a line between *Benetnasch*, the star in the point of the tail of the Great Bear, and *Denebola*, in the tail of the Lion, is α **Canum Venaticorum**, or *Cor Caroli* (3). This star is about 28° from *Denebola*, and 15° from *Benetnasch*. A little East of a line joining *Cor Caroli* and *Denebola* is the constellation Coma Berenicis.

About 26° from the *Pole Star*, and nearly in a line joining it and *Arcturus*, is α DRACONIS, (4). About 19° E.N.E. of *Arcturus*, and nearly in a line with *Dubhe* and *Mizar*, is α Coronæ Borealis, or **Alphacca** (3). *Alphacca* and seven other stars of the 4th and 5th magnitudes form a circular figure, easily distinguished, and constituting the constellation of the Northern Crown.

A line from *Arcturus* through the northern part of the the Northern Crown will point out α Lyrae, or **Vega** (1). About 25° E.N.E. of *Vega* is α Cygni, or **Arided** (2). *Vega*, *Arided*, and *Altair* form nearly a right-angled triangle, the right angle being at *Vega*. *Altair* is about 34° from *Vega*, and 38° from *Arided*.

About 18° N.N.E. from *Arided* is α Cephei, or **Alderamin** (3); and 20½° E. by N. from *Alderamin* is β Cassiopeiæ (3); *Alderamin*, *Scheat*, and *Arided*, form nearly an equilateral triangle. At the distance of 5° nearly East of β Cassiopeiæ is α Cassiopeiæ, or **Schedir** (3).

Nearly in a line with *Schedir* and β Cassiopeiæ, at the distance of 19½° from *Schedir*, is γ Andromedae, or **Alamak** (2); and about 13° W.S.W. of *Alamak*, is β Andromedae, or **Mirach** (2); this star, with β Cassiopeiæ and *Alamak*, forms nearly a right-angled triangle, the right angle being at *Alamak*.

About 12° E.S.E. from *Alamak* is β Persei, or **Algol**, a remarkable *variable star*, being when brightest of the second magnitude, and diminishing to one of the fourth. About 9½° N.N.E. of *Algol* is α Persei, or **Mirfak** (2); this star may also be known by being nearly in line with *Pollux* and *Capella*, and about 19° to the W.N.W. of the latter.

A little west of a line from *Aldebaran* through *Rigel*, at the distance of 46½° from the latter star, is *α* Argûs Navis, or **Canopus** (1): this is a very bright star, and may also be known by its being a little East of a line from *Castor* through *Sirius*, and about 37½° nearly South of the latter star. About 20° N.N.W. of *Canopus*, is *α* **Columbæ** (3).

In a line from *Betelgeux* through *Sirius*, and about 73° from the latter star, are the four bright stars forming the constellation called **Crux**, or the **Cross**. About 12° E.N.E. of *α* Crucis is *β* **Centauri** (1), and 5° East of this star, is *α* **Centauri** (1).

About 42° East, a little northerly, from *α* Centauri, and 52° S. by E. of *Antares*, is *α* **Pavonis** (2).

About 40° East of *α Pavonis*, and 39° S.E. by S. of *Fomalhaut*, is *α* Eridani, or **Achernar** (1); these three stars form nearly an equilateral triangle.

A line from *Castor* through *Pollux*, will point out *α* Hydræ, or **Alphard** (2); this star is about 44° to the S.E. of *Pollux*, and 23° S.S.W. of *Regulus*. *Procyon*, *Alphard*, and *Regulus* form nearly a right-angled triangle, the right angle being at *Alphard*.

N.B.—It must be observed, that when circumpolar stars are near the meridian below the pole, the bearing or direction between the stars appears to be reversed.

CONSTELLATIONS
OF THE
NORTHERN HEMISPHERE.

THE constellations in the vicinity of the North Pole have already (p. 12—14) been described; these consist of Ursa Major, Ursa Minor, Draco, Cassiopeia, Cepheus, Camelopardus, Lynx and Auriga; the remaining constellations of the northern hemisphere are the following:—

CANES VENATICI—the Greyhounds— is the constellation immediately below or south of the tail of the Great Bear. The dogs represent the two hounds (Asterion and Chara) of Boötes, but do not belong to the ancient constellations. In the neck of one of the hounds is the principal star, frequently called Cor Caroli. (*See* Maps I and III.)

BOOTES, or the **Herdsman**, one of the ancient constellations is made up of the stars east of the Great Bear and S.E. of Cor Caroli. Its principal star, Arcturus, takes rank in splendour next to Sirius. (*See* Maps I and III.)

PERSEUS is one of the ancient constellations, and lies westward of Auriga; or a line from Polaris drawn midway between Cassiopeia and Auriga leads to its principal stars. The story represented is that of the mythical hero Perseus carrying away the head of Medusa, one of the Gorgons, which he cut off, and gave to Minerva, to be placed in the centre of her shield. Algol, or the "Demon" star of the Arabian astronomers, so called from its variability, is in Medusa's head. (*See* Maps I and II.)

Only a few of the most northern stars of the constellation **Andromeda** are represented on Map I. The constellation lies to the westward of Perseus, or on a line drawn from Polaris through Cassiopeia.

In the old mythology Andromeda was the beautiful daughter of Cepheus and Cassiopeia, who, when bound to a rock and exposed to a sea-monster, was rescued by Perseus, and became his wife. Being one of the old constellations, it naturally comes close to those with which it is mythologically connected. (*See* Maps I, II and III.)

CYGNUS, the **Swan**, one of the ancient constellations, is southward of Cepheus, on a line drawn through it, and extending from Polaris. Its five principal stars form a *cross* in the Milky Way. (*See* Maps I and III.)

Lacera, the **Lizard**, is an inconspicuous constellation between Andromeda and Cygnus. (*See* Maps I and III.)

LYRA, the **Lyre**, is on a line drawn from Polaris through that part of the body of the Dragon which lies near Cepheus, and is on the opposite side of the pole to Auriga. Its principal star is Vega which, of the stars of the northern hemisphere, ranks next to Capella in brilliancy. (*See* Maps I and III.)

Triangulum, the **Triangle**, is an inconspicuous constellation south-eastward of Andromeda, and north-westward of Aries, one of the constellations of the Zodiac. (*See* Map II.)

Musca, the **Northern Fly**, a constellation not generally recognised, between Triangulum and Aries, was made up of some stars detached from, but properly belonging to, Aries (*See* Map II.)

Leo Minor, the **Lesser Lion**, is a constellation formed by a group of small stars south of the Great Bear, between it and Leo, one of the constellations of the Zodiac. (*See* Map II.)

Coma Berenicis is a group of small and tolerably bright stars to the southward of Cor Caroli, and westward of Arcturus. (*See* Map III.)

HERCULES is a large constellation on the opposite side of the pole to Auriga and south-westward of Lyra. Its principal star, Ras Algethi (*α*), is a variable one. (*See* Maps I and III.) The constellation was named after the mythological hero of the same name.

CORONA BOREALIS, the **Northern Crown**, is a circlet of tolerably conspicuous stars between Hercules and Boötes: it is on the opposite side of the pole to Perseus. (*See* Maps I and III.)

OPHIUCUS, sometimes called **Serpentarius**, or the **Serpent Bearer**, is one of the ancient constellations, represented under the figure of a man with a large beard, holding a serpent (sacred to medicine) in his hand. Its principal star *α*, or Ras Alhague, in the head, is close to the principal star in Hercules. (*See* Map III.)

SERPENS, the **Serpent,** one of the ancient constellations, winds from Corona Borealis, in R. A. 15⅔ h., through Ophiucus, to the vicinity of Aquila in R. A. 19h. The Equator passes through Ophiucus and Serpent. (*See* Map III.)

AQUILA, the **Eagle,** lies S.S.E. from Vega in Lyra, and S.S.W. from the constellation Cygnus. Its principal star, α Aquilæ (Altair), is on the edge of the Milky Way, and is one of the stars tabulated in the "Nautical Almanac" for *Lunar Distances.* (*See* Map III.)

Delphinus, the **Dolphin,** is a group of diamond-shaped stars, very bright, though small, lying to the north-eastward of Altair. (*See* Map III.)

Vulpecula et Anser, the **Fox and Goose,** is a constellation composed of many small stars lying southward of Cygnus, and northward of Aquila and Delphinus. (*See* Map III.)

Sagitta, the **Arrow,** is an ancient constellation formed by a line of small stars about 10° north of Altair in Aquila, and to the eastward (northerly) of Ras Algethi and Ras Alhague, the principal stars in Hercules and Ophiucus. (*See* Map III.) It was named after the arrow with which Hercules killed the vulture that preyed on the liver of Prometheus, when he was chained to the rock for stealing the sacred fire from heaven.

Taurus Poniatowski—Poniatowski's Bull—is a constellation formed by a group of small stars nearly midway between Altair in Aquila, and Ras Algethi in Hercules. (*See* Map III.)

PEGASUS, the **Winged Horse,** which sprang from the blood of Medusa, when her head was struck off by Perseus, lies to the south-westward of Andromeda, and south-eastward of Cygnus. (*See* Maps II and III.) When the Great Bear is on the meridian *below* the pole in our latitude, Pegasus and Andromeda are on the meridian *above* the pole: the four principal stars (α, β, γ Pegasi, and α Andromedæ), which form the *square* of Pegasus, are then opposite to the *square* of the Great Bear.

The star Markab, or α Pegasi, at the S.W. angle of the square, is one of the stars for which *Lunar Distances* are tabulated in the "Nautical Almanac."

Equuleus, the **Little Horse,** is an inconspicuous constellation westward of Enif (ε) in the head of Pegasus, and at the south extremity of Delphinus. (*See* Map III.)

THE ZODIACAL CONSTELLATIONS.

The *Zodiacal Constellations*—twelve in number—lie between the constellations of the northern and southern hemispheres, and are in the ancient list given by Aratus. It is probable however that the Greeks adopted them from the old Chaldean astronomers. The figures by which they are still represented are similar to those delineated on the ceiling of an apartment in the temple of Dendera, in Egypt, which dates from about 700 years before our era.

In naming and delineating the zodiacal constellations the ancients were probably guided by the incidents of life, and by various natural phenomena, occurring at the time of the sun's appearance in particular parts of the heavens. Thus the Bull was useful in ploughing in spring: the Crab, walking backwards, indicated the recession of the sun from the northern tropic: the Lion represented the intensity of summer heat: the Virgin, with the spike of corn, referred to the gleaning time at harvest: the Balance marked the equality of day and night at the equinox: the Scorpion told of disease incident to the falling year, and Aquarius, of rain and winter: besides which all had a mythological significance—thus, Sagittarius represented the Centaur Chiron, half-horse, half-man, who was wounded in the knee with a poisoned arrow by Hercules, and placed among the constellations.

It may be remarked here, that the *signs of the zodiac must not be confounded with the constellations of the zodiac,* for though at the time of the naming of the latter, the signs were in the respective constellations whose names they bear, this is no longer the case. Owing to the precession of the equinoxes, and the consequent retrograde motion of the First Point of Aries along the ecliptic, that point is now in the constellation Pisces. The signs are purely technical subdivisions of 30° each commencing from that point where the ecliptic is intersected by the equinoctial in the spring; and the symbols, as ♈, ♉, &c. now properly appertain to the *signs* of the zodiac and *not* to the constellations.

The *First Point of Aries* is the *Vernal Equinoctial Point,* commencing in the sign of the ecliptic of the same name, and is now in the constellation Pisces. It is the point where the Sun crosses the Equator in March, and is the origin, or zero point, whence Right Ascension is reckoned on the Equinoctial, and Longitude on the Ecliptic.

The *First Point of Libra* is the *Autumnal Equinoctial Point,* commencing in the sign of the ecliptic of the same name, and is now in the constellation Virgo. It is the point where the Sun crosses the Equator in September.

The *First Point of Cancer* is the *Summer Solstitial Point,* commencing in the sign of the ecliptic of the same name, and is now in the constellation Gemini. It marks the spot where the Sun attains its maximum *northern* Declination. The northern Tropic is named after the sign.

The *First Point of Capricorn* is the *Winter Solstitial Point,* commencing in the sign of the ecliptic of the same name, and is now in the constellation Sagittarius. It marks the spot where the Sun attains its maximum *southern* Declination. The southern Tropic is named after the sign.

ARIES, the **Ram,** the first constellation of the ancient zodiac, indicated the period for the commemoration of the mythical Argonautic expedition to carry off the Golden Fleece. Two conspicuous stars, 4° apart, mark the head of the Ram, α and β, named respectively by the Arabic astronomers, Hamel and Sheratan: α Arietis, the most northern of the

two stars, is one for which *lunar distances* are tabulated in the Nautical Almanac. (*See* Map II.)

TAURUS, the **Bull**, the second and one of the finest of the zodiacal constellations, comes next in order to Aries. It lies south of Auriga and Perseus, and N.W. of Orion, and contains two groups of small stars, the Pleiades and Hyades, which are often mentioned by the ancient poets, the first group being also alluded to in the book of Job.

The principal star, Aldebaran, though of the first magnitude, being of a ruddy colour, is not brilliant: it is one of the Hyades, which, being in shape like the letter V, form the face of the Bull. The Hyades were supposed to indicate rain, and were also known as the Suculæ, or *Little Pigs*. Aldebaran is one of the stars for which *lunar distances* are tabulated in the Nautical Almanac.

The Pleiades are in the shoulder of the Bull, and form a cluster of small, contiguous stars that glisten with a remarkable degree of brightness: to an ordinary eyesight only six are visible, but some are able to detect a seventh; viewed with a telescope many more are seen. They were supposed to indicate the season favourable to navigation. The Romans called them the Vergiliæ, as in Cicero's translation of Aratus—

"You will see the little Vergiliæ faintly shining; these are commonly said to be seven in number, after the ancient tradition, but only six small stars are seen;"—the reference being to the story of the lost Pleiad. (*See* Map II.)

GEMINI, the **Twins**, the third zodiacal constellation and next to Taurus, lies S.E. of Auriga. Its two principal stars are Castor and Pollux, about $4\frac{1}{2}°$ apart; they were anciently much noticed, especially by mariners. When the planet Uranus was first discovered, it was in this constellation. Pollux is one of the stars for which *lunar distances* are tabulated in the Nautical Almanac. (*See* Map II.)

CANCER, the **Crab**, the fourth zodiacal constellation lies next to Gemini, and contains no very conspicuous star. The two Aselli (Asses) are of mag. 4; and between them is the nebulous cluster of stars called Præsepe (or the *Beehive*), only visible on very clear nights. Acubens (α Cancri) is a small star E. N. E. (21°) from Procyon in Canis Minor. (*See* Map II.)

LEO, the **Lion**, is the fifth zodiacal constellation, and the stars composing it are sufficiently conspicuous. Regulus, or Cor Leonis (α), is one of the stars for which *lunar distances* are tabulated in the Nautical Almanac. Denebola, the next important star, is in the tail. The group of stars (α, η, γ, ζ, μ, ϵ, and λ) stretching from Regulus (α), first northward then in a semi-circular form towards the east, north, and west has been known as the *Sickle*. (*See* Map II.)

VIRGO, the **Virgin**, the sixth zodiacal constellation, is, like Leo, a conspicuous one; and its principal star Spica Virginis is one of the stars for which *lunar distances* are tabulated in the Nautical Almanac. Spica having no other star of equal magnitude near it was called by the Arabian astronomers *Al-simak-al-azal* or the "*defenceless one*": Vindemiatrix (ϵ) is also another conspicuous star in this constellation: both lie to the southward and westward of Arcturus and Boötes. To the N.W.-ward of Spica lies a semi-circular group of stars (β, η, γ, δ and ϵ) called, by the Arabian astronomers, the *Retreat of the Howling Dog*. (*See* Map III.)

LIBRA, the **Balance**, the seventh zodiacal constellation, is marked by four small stars, two in each balance: Zuben-el-Genubi (β) in the *northern* balance lies east (northerly) 26° from Spica in Virgo: Zuben-el-Chamali (α^2) in the *southern* balance lies $9\frac{1}{2}°$ S.W.-ward of Zuben-el-Genubi, and E. by S. (21°) from Spica: both are under mag. 2. (See Map III.)

SCORPIO, the **Scorpion**, the eighth zodiacal constellation, is composed of several beautiful stars, among which Antares, of mag. 1, in the body of the figure, is of a red hue, and very conspicuous. The stars to the westward of Antares, and trending nearly north and south, form the claws of the Scorpion: from Antares, a trail of stars towards the S.E.-ward, trending into the Milky Way, forms the tail of the Scorpion, the principal star being Lesath (λ) 18° S.E.-ward of Antares. Antares is one of the stars for which *lunar distances* are tabulated in the Nautical Almanac. (*See* Map III.)

SAGITTARIUS, the **Archer**, composed of stars of the second, third, and fourth magnitudes, is the ninth zodiacal constellation, and lies south of Ophiuchus, Serpens, and Aquila; five of these stars, forming a line in the Milky Way, have been called the *milk-dipper*. The stars μ, λ, δ, ϵ, β, which form an irregular curve in the eastern branch of the Milky Way, and lie eastward of Antares, are in the bow of the Archer; beyond these, σ, τ, ζ, ϕ, form a quadrangular figure in the body of the Archer. (*See* Map III.)

CAPRICORNUS, the **Sea-Goat**, the tenth zodiacal constellation, has no stars exceeding the third and fourth magnitudes, and is comparatively inconspicuous from having no definite figure: it consists of the group of stars south of Altair in Aquila and Enif in Pegasus. Its two principal stars α^2 and β are a little westward of a line produced from Vega through Altair (distant 23° from the latter); and δ in the fish-like tail of the sea-goat (hence called Deneb Algiedi) lies nearly due south of Enif (ϵ) in Pegasus, at the distance of 26°. The star β in Capricornus was *formerly* one of those from which lunar distance were tabulated in the Nautical Almanac. (*See* Map III.)

AQUARIUS, the **Water-Bearer**, the eleventh zodiacal constellation, like Sagittarius and Capricornus, occupies a wide area in the heavens with stars of the third, fourth, and less magnitudes. It lies southward of Markab and Enif in Pegasus, and a group of stars in the form of the letter Y to the S.E.-ward (14°) of Enif (ϵ) in Pegasus constitute the *water-pot*. (*See* Map III.)

PISCES, the **Fishes**, the twelfth and last of the zodiacal constellations, is an assemblage of small stars, none exceeding the fourth magnitude. The northern fish is just south of Mirach (β) in Andromeda, and west of α Arietis: the southern fish lies south of Markab and Algenib in Pegasus. In this constellation commences the vernal equinox (First Point of the *sign* Aries), south (14°) a little westerly of Algenib. (*See* Map II.)

Referring to Map II it will be seen that no conspicuous star in Pisces marks the First Point of Aries, or Vernal Equinoctial Point. The Ecliptic runs considerably south of α Arietis, thence between the Pleiades and Hyades in Taurus. The summer Solstitial Point, or First Point of Cancer, is close to η and μ Geminorum, whence the Ecliptic trends towards Regulus in Leo. The Equator passes between Menkar and Mira in Cetus, thence just to the north of the northernmost star of Orion's belt, and a few degrees south of Procyon in Canis Minor.

Referring to Map III, the Autumnal Equinox, or First Point of Libra, is seen close to (westward of) η Virginis. The Ecliptic passes a little northward of Spica in Virgo, close to α Libræ in the southern Balance, and a little south of β Scorpii, thence towards μ Sagittarii, immediately below which is the Winter Solstice, or First Point of Capricorn: from this point its direction is to the southward (a few degrees) of β Capricorni. The Equator is marked by η Virginis, but no other conspicuous star lies near it: Altair in the Eagle is 8° north of it.

CONSTELLATIONS OF THE SOUTHERN HEMISPHERE.

Of the forty-six recognized constellations of the southern hemisphere only fifteen were known to the ancients, and these, like the constellations of the northern hemisphere, had a mythological significance. The remaining, or modern, constellations have been designated, some out of the unformed stars within the ken of the ancients, and others out of the groups surrounding the South Pole, which were beyond the visual range of the early astronomers.

Orion and the Southern Cross (Crux) have already been described on page 14. It may be remarked that Canis Major, Canis Minor, and Lepus, being animals connected with hunting, are naturally placed in the vicinity of Orion, the renowned hunter. As before said, the ancients knew of the stars forming Crux, but they were considered to constitute part of Centaurus.

CETUS, the **Whale**, lies west of Orion, and southward of Aries and Pisces. It represented the sea monster sent by Poseidon (Neptune) to devour Andromeda, because her mother Cassiopeia had boasted of her being fairer than the Nereids. Perseus slew the monster; hence, naturally, Cetus comes near Andromeda and Perseus, being separated from them only by the zodiacal constellations. (*See* Map II.) It contains several conspicuous stars, especially one, Mira, which is variable.

ERIDANUS, is the **River Po**, celebrated in the ancient mythology as the river into which Phaethon was precipitated when he nearly set the world on fire, through his unskilful driving of the fiery coursers of the sun through the zodiac. The constellation forms a band extending from near the equator, between Cetus and Orion, to Dec. 60° S. (*See* Maps II. and IV.) The principal star is Achernar, of mag. 1.

LEPUS, the **Hare**, is at the feet of Orion. (*See* Map II.) The stars are small: one is of mag. 3.

CANIS MINOR, the **Little Dog**, is due south of Castor and Pollux in Gemini, and east of Betelgeux and Bellatrix in Orion. It contains but two distinguishable stars, one of which, Procyon, is very bright. (*See* Map II.)

CANIS MAJOR, the **Greater Dog**, one of the ancient constellations, is situated to the S.E.-ward of Orion, and contains the brightest star in the heavens, Sirius, or the *Dog Star*, which lies nearly in a line with Aldebaran and Orion's *belt*. Sirius is at the nose of the Dog, and 6° W. by S. from it is β Canis Majoris of mag. 3, in the paw: to the S.S.E. of these, and near the hinder quarters of the Dog are two other conspicuous stars, δ and ϵ, of mag. 2; the four stars forming an irregular quadrilateral figure. (*See* Map II.)

In ancient times, the forty days commencing in the first week of July and ending in the second week of August were termed the Dog Days, from being marked by the heliacal rising of Sirius, that is, they were reckoned to last from the twentieth day before to the twentieth day after the one on which the star rose at the same minute as the sun; and the period was supposed to be most fatal in producing fever and various diseases, together with madness: this heliacal rising of Sirius was also an event of importance to the Egyptians as it indicated the time of the rising of the waters of the Nile. The superstition of the malarious influence of this star at the particular period named passed to Greece, and thence to Rome, whence the term *Cynic* days among the Greeks, and *Canicular* days among the Romans; and so the superstition passed on to other countries and has lasted to the present day, even among those who should know better; for instance, almanacs tell us that the forty "Dog-Days" still commence on the 3rd of July, and end on the 11th of August: but this is impossible, if the heliacal rising of Sirius is to be taken as the base of the date, since, owing to the latitude and the precession of the equinoxes, that phenomenon now occurs about the second week of August; consequently the classical Dog-Days as marked by the star Sirius begin with us towards the end of July and terminate at the beginning of September.

But the "Dog Days" are chiefly to be noted on account

of their chronological importance with reference to the "Great Year" of the ancient Egyptians:—"The *Great Year* of the Egyptians was not determined by the Moon, but by the fact of their civil year containing always 365 days, without any leap year, which caused a slow change of the seasons, in consequence of the year being nearly six hours shorter than it ought to have been. This change was completed in 1461 years, at the end of which period the seasons all came back to their proper places in the year. This period of 1461 years was called the Great Year; also, by the Greeks, the *Cynic*, or Dog Year; and by the Latins, the *Canicular* Year, because it began when the Dog Star rose at dawn, on the first day of the Egyptian month *Thoth*. But the year which Aristotle calls *the Greatest*, rather than *the Great*, is that in which the Sun, Moon, and Planets all return and come together in the same sign of the Zodiac from which they originally started. The winter of this year is the *Cataelysm*, or Deluge; the summer is the *Ecpyrosis*, or Conflagration of the World."

So, also, Humboldt observes that, "according to the most recent researches, the Sothic period and the heliacal rising of Sothis (Sirius), remove the complete construction of the Egyptian calendar to the highly ancient epoch of almost 33 centuries before our era, when not only the summer solstice, and consequently the commencement of the rising of the Nile, but also the heliacal rising of Sothis fell upon the day of the first water-month."—Humboldt's *Cosmos*.

COLUMBA, the **Dove**, sometimes called Columba Noachi, or Noah's Dove, is a modern constellation, situated to the south of Orion, and Lepus, and S.W. of Sirius. Its principal star (α) is of mag. 3. (*See* Map II.)

ARGO NAVIS, the **Ship Argo**, is one of the ancient constellations named after the famous vessel that carried Jason and his companions to Colchis in quest of the Golden Fleece. The constellation occupies a wide area in the heavens, to the eastward and S.E.-ward of Canis Major, extending from Dec. 10° S. to 60° S., between R. A. 7 h. and 10½ h. It has many conspicuous stars, of which Canopus (α) is the chief; and η Argûs is variable. Sir John Herschel subdivided the constellation into Carina (the *keel*), Puppis (the *stern*), Malus (the *mast*), and Vela (the *sails*). (*See* Maps II. and IV.)

HYDRA, was named after the *Lernean* Hydra, with nine heads, killed by Hercules, as one of his twelve labours, and in the blood of which he poisoned his arrows. The constellation has great length, extending from Dec. 9° N. to 35° S., between R.A. 8 h. and 14 h., south of Leo and Virgo. It has but one conspicuous star, Alphard. (*See* Maps II & III.)

CRATER, the **Goblet**, represents the cup from which Jupiter, Neptune and Mercury drank when entertained by a peasant of Bœotia. The constellation is near the middle of the body of Hydra; and nearly south of Denebola in Leo. (*See* Map II.) Its principal star does not exceed mag. 3.

CORVUS, the **Crow**, is near the tail of Hydra. Its origin is uncertain. (*See* Map III.) Crater and Corvus, though they contain many stars, have none of greater mag. than 3. The principal stars in Corvus form a quadrilateral figure.

Monoceros, the **Unicorn**, is a modern constellation made up of the unformed stars between Orion, Canis Minor, Canis Major and Hydra. None are conspicuous. (*See* Map II.)

Sextans, the **Sextant**, between Leo and Hydra, has no conspicuous stars. (*See* Map II.)

CENTAURUS, the **Centaur**, is an ancient constellation, representing the Centauri, half-horse and half-man, which were said to be the offspring of Ixion and a cloud. It is due south of Spica in Virgo, and has many fine stars. The ancients considered Crux (the *Croziers*) as part of it. (*See* Maps III and IV.) The two principal stars (α and β) are on the opposite side of the South Pole to Achernar in Eridanus.

LUPUS, the **Wolf**, is a small but ancient constellation, southward of Libra and Scorpio, and N.E. of the principal stars in Centaurus. It has three stars of mag. 3. (*See* Maps III and IV.)

Norma and **Telescopium** or **Tubus** are near the tail of Scorpio. (*See* Map III.)

Scutum Sobieski is made up of stars east of Serpens and Ophiucus. (*See* Map III.)

Microscopium lies east of Sagittarius. (*See* Map III.)

PISCIS AUSTRALIS, the **Southern Fish**, is an ancient constellation, named from the transformation of Venus into that form when pursued by the monster Typhon. It has one very conspicuous star, Fomalhaut, which is tabulated in the Nautical Almanac for *lunar distances*. The constellation lies south of Aquarius. Fomalhaut, in Arabic, means the *fish's mouth*, and it is situated nearly due south of Markab in Pegasus. (*See* Map III.)

GRUS, the **Crane**, a modern constellation, lies south of Piscis Australis, and has one conspicuous star of mag. 2. It is on the opposite side of the South Pole to Argo Navis. (*See* Maps III and IV.)

Phœnix, a modern constellation, between Grus and the south end of Eridanus, has no remarkable star. It is on the opposite side of the South Pole to Centaurus. (*See* Maps II. and IV.)

ARA, the **Altar**, an ancient constellation, represents the altar before which the ancient gods swore previous to their battle with the giants. Its principal stars are sufficiently

conspicuous, being of mag. 3 and 4; they are nearly in a line (S. and N.) and pass the meridian about the same time. (*See* Map IV.)

PAVO, the **Peacock**, is a modern constellation, south-eastward of Ara, and due south of Aquila and Sagittarius. It has one conspicuous star of mag. 2. (*See* Map IV.)

TRIANGULUM AUSTRALE, the **Southern Triangle**, is a modern constellation, and has three conspicuous stars S.E. of Centaurus, and S.W. of Ara, not far from α Centauri, one of mag. 2. (*See* Map IV.)

Hydrus and **Dorado**, within 30° of the South Pole, are remarkable as containing some noted nebulæ. They lie S.S.W. from Canopus in Argo Navis. The most conspicuous star near the South Pole is β Hydri (of mag. 3) in Dec. 78° S. (*See* Map IV.)

Corona Australis, the **Southern Crown**, southward of Sagittarius, and S.E.-ward from Antares in Scorpio, has but a faint resemblance to the Northern Crown. (*See* Map IV.)

Musca and **Toucanus** have each a star of mag. 3; **Indus** and **Dorado** have each a star of mag. 4 (*see* Map IV.); otherwise they are not conspicuous.

The constellation **Chamæleon** is near the South Pole, and has a star (β) of mag. 5 within 11½° of the Pole. (*See* Map IV.)

Octans occupies the region of the South Pole, but has no conspicuous star; one (σ) of mag. 6 is within a degree of the Pole. (*See* Map IV.)

For **CRUX**, the Southern Cross, *see* p. 14.

The remaining constellations have no particularly remarkable stars, but may be found by referring to Map IV. and the catalogue of constellations on p. 4.

A few brief instructions will now point out the principal stars by means of the Star-Maps which accompany this work.

MAP I.—PRINCIPAL STARS IN THE NORTHERN CONSTELLATIONS.

Ursa Major and **Ursa Minor**, with their principal stars are fully described on p. 12 and 13.

The brightest stars in this region are ARCTURUS in Boötes, CAPELLA in Auriga, and VEGA in Lyra.

Polaris or the POLE STAR.—A line from β Ursæ Majoris through Dubhe, (the *Pointers*), produced to about five times their distance (29°), will terminate very near the Pole Star.

α DRACONIS.—A line from γ through δ in Ursæ Majoris, continued to nearly three times their distance (15°), will lead to α in *Draco*. This star lies midway in a line between Mizar (the middle star in the tail of the Great Bear) and the southern *guard* in the Little Bear, named Kochab.

Arcturus.—A line from Dubhe passing between γ and δ Ursæ Majoris leads to Arcturus in *Boötes:* it is also W. by S., 20° from Alphacca, in Corona Borealis, and about as far to the eastward of the *southern Pointer* as Capella is to the westward of it. Arcturus is remarkably bright.

MIRAC in BOÖTES.—A line from Mizar through Benetnasch (in Ursa Major), continued 25° from the latter, will lead to Mirac, in *Boötes*.

SEGINUS in BOÖTES.—About N. by E. of Arcturus at the distance of 20° is Seginus or γ in *Boötes*, in the west shoulder: it is also nearly East 19° from Cor Caroli. The stars Cor Caroli, Seginus, and Alioth in the tail of the Great Bear, form nearly a right angled triangle, with the right angle at Cor Caroli.

Alphacca or ALPHETA.—A line from Polaris through γ Ursæ Minoris, the southernmost *guard* of the Little Bear, leads to Alphacca in *Corona Borealis*. It is also E. by N. 20° from Arcturus in Boötes.

Cor Caroli.—A line from α in Draco through Mizar, continued to once and a half their distance, will point out the star Cor Caroli, or α *Canum Venaticorum*. The above line, projected in the opposite direction, to about the distance of Mizar to α in Draco, will terminate at the southern *guard* in Ursa Minor. Also, a line from Dubhe through γ in Ursa Major, continued to about twice their distance (18°), will terminate a little to the westward of Cor Caroli. The stars Cor Caroli, Arcturus, and Alphacca form a right-angled triangle, the right angle being at Arcturus. Cor Caroli bears due South, distant 18° from Alioth, in Ursa Major, and consequently comes to the meridian at the same time with it.

VINDEMIATRIX.—A line from Alioth through Cor Caroli, continued to about once and a half their distance (28°), will lead to Vindemiatrix, or ε *Virginis*.

DENEBOLA.—A line from Benetnasch through Cor Caroli, produced to twice their distance (29°), will terminate at the star Denebola, or β *Leonis*. Or a line from Dubhe, the northern Pointer, passing β Ursæ Majoris, about 2° to the eastward, and continued to the distance of 43°, will lead to the same star. Vindemiatrix, Cor Caroli, and Denebola form an isosceles triangle.

COMA BERENICES.—A line from Benetnasch through Cor Caroli, and produced to about once their distance, will lead to the cluster of stars named *Coma Berenices*. The stars Benetnasch, Cor Caroli, Coma Berenices, and Denebola are nearly in the same line, and equi-distant from each other.

Regulus.—A line from δ passing west of γ Ursæ Majoris, and continued 46°, will lead to Regulus, or α *Leonis*.

Vega.—A line from γ passing between δ and ϵ Ursæ Majoris leads to Vega in *Lyra*, readily distinguished by its brightness.

ETANIN.—Between the square of Ursa Minor and the star Vega in Lyra, rather more than half way towards the latter, are four stars forming a quadrilateral figure in the constellation *Draco:* of these, that nearest to Vega, is called Etanin or γ *Draconis*. A line from Altair, through Vega, and produced to about half their distance (15°), will pass through β in *Draco*, and about 3° to the westward of Etanin; this line continued to once and one-third the distance between Altair and Vega will lead to α in *Draco*.

Arided.—About E.N.E., 24° from Vega is Arided, or α *Cygni*. A line from Algenib, in Pegasus, through Scheat, continued to once and two-thirds their distance (33°), will lead to the same star. The four principal stars in the constellation Cygnus form the figure of a large cross. Vega, Etanin, and Arided form a right-angled triangle, the right angle being at Vega.

CASSIOPEIA.—A line from Alioth in Ursa Major, through the Pole Star, and continued to about four-fifths their distance (29°), will lead to the star γ in *Cassiopeia*. This star, with others on either side, forms the figure of a broad W, and are the principal stars in the constellation; that farthest from the Pole Star being named *Schedir*. A line from δ in the square of the Great Bear, through the Pole Star, produced to rather less than once their distance (30°), will lead to β in *Cassiopeia*. This constellation is situated as far on one side of the North Pole as the Great Bear is on the opposite.

ALDERAMIN.—A line drawn from Schedir through β in Cassiopeia, and continued to rather more than three times their distance (25°), will terminate about 2° northward of Alderamin in *Cephcus*.

ALMACH.—A line from Alderamin, passing 1° below Schedir, and continued to about three-fourths their distance (19°), will lead to Almach, or γ in *Andromeda*; or a line from β in Cassiopeia through Schedir, and continued to four times their distance (19°), will point out the same star.

Alpherat.—A line from the Pole Star through β in Cassiopeia, continued to once their distance (30°), will lead to Alpherat, or α in *Andromeda;* and all three stars come to the meridian very nearly at the same time.

MIRACH.—Midway between Alpherat and Almach, and nearly in a line with them, is the star Mirach, or β in *Andromeda*.

SCHEAT.—West 14° from Alpherat lies Scheat, or β in *Pegasus*.

Algenib.—A line from β Cassiopeia through Alpherat leads to Algenib, or γ Pegasi.

Markab.—A line from the Pole Star through Scheat will lead to Markab in *Pegasus*.

Mirfak, or ALGENIB in Perseus.—A line from Mirach through Almach, continued to rather more than once their distance (16°), will terminate a little to the southward of Mirfak, or α in *Perseus*, which lies in the middle of the Milky Way. This star is attended by two smaller stars, one on each side, forming a curved line with it; these are called the *Bow of Perseus*. The stars Alpherat, Mirach, Almach, and Mirfak are nearly equidistant, and form an arc of a large circle.

Algol.—About 10° to the South of Mirfak in Perseus is the star Algol, the principal of a cluster in *Caput Medusæ*. this star varies its apparent magnitude periodically. Algol forms a right-angled triangle with Almach and Mirfak, the right angle being at Algol.

Capella.—The brightness of this star readily distinguishes it: a line from Almach, passing midway between Mirfak and Algol, and produced to the distance of 34°, will lead to Capella in *Auriga*; and this line continued 8° will terminate a little to the southward of β in the same constellation. A line from γ in Ursa Major (the south-eastern star in the *square*), drawn midway between the *Pointers*, and produced to the distance of 60°, will lead to the same star.

To the southward of Capella are three stars, forming a small but conspicuous triangle on the edge of the Milky Way, and known as Hædi or the *Kids*.

Castor and **Pollux.**—E. by S. 30° from Capella, is the star Castor, or α in *Gemini;* and S. E. by S., $4\frac{1}{2}$° from this star, is Pollux, or β in *Gemini*.

Aldebaran.—A line from the Pole Star passing nearly midway between Algenib and Capella will lead towards Aldebaran in *Taurus*.

Altair.—A line from the Pole Star passing midway between Vega and Arided will lead to Altair in *Aquila*.

MAPS II. & III.—THE PRINCIPAL STARS IN AND NEAR THE ZODIAC.

Orion.—This constellation and its stars have already been described on p. 14.

Aldebaran.—A line drawn from Betelgeux through the stars in the *head* of Orion, to three times their distance (26°), will lead to Aldebaran, or α in *Taurus*. This star may also be known by four smaller stars which together form the letter V.

PLEIADES.—A line drawn from Betelgeux, through the stars in the *head* of Orion, and Aldebaran, to nearly three-fourths the distance of the two latter (14½°), will terminate a little to the southward of the *Pleiades*, a remarkable cluster, consisting apparently of six small stars, but very numerous when viewed through a teleseope. A line through the stars in the *belt*, produced north-westerly, will also point out the Pleiades.

NATH or β TAURI.—A line from the middle star in the *belt*, through the stars in the *head* of Orion, produced to twice the'r distance (20°), will lead to β in *Taurus;* and this line continued to nearly the same distance (17°), will lead to Capella, in the constellation Auriga.

α ARIETIS.—West of the Pleiades, at the distance of 23°, is the star α *Arietis*, or HAMEL; it may be distinguished by two smaller stars to the S.W. of it, the larger one being distant about 4°.

Menkar.—S.W. by S. from the Pleiades, distant 23°, is the star Menkar, in *Cetus*, it is also nearly in a line with the stars Betelgeux and Bellatrix, in the *shoulders* of Orion, and 37° from the latter. The Pleiades, α Arietis, and Menkar, form an equilateral triangle.

Mira.—A line from Aldebaran through Menkar, to somewhat less than half their distance (13°), will terminate a little to the northward of Mira, in *Cetus*, which is a variable star. To the south-westward of this are four smaller stars forming a quadrangle.

MIRACH.—A line from Menkar passing α Arietis a little to the westward, and continued to three-fourths their distance (17°), will point out Mirach in *Andromeda.*

Sirius.—A line drawn south-eastward, through the stars in the Orion's *belt*, to the distance of 23° from the middle star, will lead to Sirius, or α *Canis Majoris;* also a line from the Pleiades, through the stars in the *belt*, will lead directly to the same star. Sirius can always be known by its peculiar brightness.

CANIS MAJOR.—S.E. by S. 12° from Sirius, is the star δ *Canis Majoris;* or a line from Betelgeux through Sirius, continued nearly to half their distance (12°), will lead to the same star, which forms a small triangle with two others in the same constellation: the star to the south-westward is ε, and that to the south-eastward η *Canis Majoris:* also W. by S. 6° from Sirius is β in *Canis Major.*

Procyon.—Nearly East from Betelgeux, at the distance of 26°, is the star Procyon, or α *Canis Minoris.* The stars Betelgeux, Procyon, and Sirius form an equilateral triangle to the southward; and the stars Pollux, Procyon, and Betelgeux form nearly a right-angled triangle to the northward, the right angle being at Procyon.

ACUBENS.—A line from Capella through Pollux leads to Acubens or α in *Cancer:* it is also nearly in a line with Betelgeux and Regulus, and much nearer the latter.

Pollux and **Castor.**—Nearly North of Procyon, at the distance of 23°, is the star Pollux; nearly N.W. from which is Castor, both in the constellation *Gemini.* A line from Rigel, through the middle star of Orion's *belt*, produced to nearly twice the distance of Rigel from Betelgeux (34°), will also lead to Castor.

Regulus.—A line from Betelgeux passing β in Canis Minor, about 2° to the northward, and produced 40° from the latter star, will terminate at Regulus, or α *Leonis;* a line also from the middle star in Orion's *belt*, through Procyon, continued to rather more than once their distance (or 38° from the latter), will lead to the same star.

ALPHARD.—S.E. by E. 31° from Procyon, and S.S.W. 23° from Regulus, is the star Alphard, or α in *Hydra*, called also Cor Hydræ. Sirius, Procyon, and Alphard form nearly an isosceles triangle, the angle at Procyon being obtuse. Also the stars Alphard, Regulus, and Procyon form a right-angled triangle, the right angle being at Alphard.

DENEBOLA.—A line from Procyon, through Regulus, produced to two-thirds their distance (25°), will lead to Denebola, or β in *Leo.* Procyon, Regulus, and Denebola are all nearly in a line.

COMA BERENICES.—N.E. about 14° from Denebola, is a remarkable cluster of small stars, named *Coma Berenices.*

VINDEMIATRIX.—E. by S. 19° from Denebola in Leo, is the star Vindemiatrix, or ε in *Virgo*, which, with Denebola, and the cluster of Coma Berenices, form nearly an equilateral triangle.

Spica Virginis.—S.E. 35° from Denebola, is the bright star Spica or α *Virginis;* below which, and very near to it, is a small star of mag. 4.

ALGOREB.—W.S.W. 14° from Spica, is the star δ in *Corvus*, called Algoreb. The principal stars in the constellation form a quadrangle; Algoreb, the north-easternmost, is in a line with γ (the north-westernmost), and the star Spica.

Arcturus.—A line from Procyon, through Regulus and Denebola, produced to once and nearly a half the distance of the two latter (35°), will terminate about 5° to the southward of Arcturus in *Boötes.* Arcturus, Denebola, and Spica form an equilateral triangle.

MIRAC.—N.E. 10½° from Arcturus, is the small star Mirac in *Boötes.*

Alphacca.—A line from Vindemiatrix, through Arcturus, continued to once their distance (20°), will lead to Alphacca,

the principal star in the constellation *Corona Borealis*, which, with six smaller stars, forms the figure of a *crown*. Alphacca, Mirac, and Arcturus form an isosceles triangle, the angle at Mirac being very obtuse

Unuk.—S.E. by E. 25° from Arcturus, and south a little easterly, 21° from Alphacca, is the star Unuk, or α in the *Serpent*. Arcturus, Alphacca, and Unuk form nearly an equilateral triangle.

Libra.—The principal stars in Libra are described on p. 18; Zuben-el-Chamali the chief star in the *Southern Balance* lies E. by S. 21° from Spica, and S.S.W. from Unuk.

Antares.—A line from Spica passing Zuben-el-Chamali, in the *Southern Balance*, about five degrees to the southward, and continued to once and one-third their distance (27°), will lead to Antares, or α in *Scorpio*, which star may also be distinguished by two small stars, one on each side of it, nearly equidistant, and forming with it a large obtuse angle. A line drawn north-westerly through these stars to the distance of 25° from Antares, will point out Zuben-el-Gennbi, in the *Northern Balance*. Antares, and the two principal stars in Libra form a right-angled triangle, the right angle being at Zuben-el-Gennbi.

Ras Algethi.—S.E. by E. 26° from Alphacca, in *Corona Borealis*, is Ras Algethi, the principal star in the constellation *Hercules*.

Ras Alhague.—A line from Alphacca, through Ras Algethi, continued to one-fourth their distance (6°), will give the star Ras Alhague in *Ophiuchus*. This star is situated E. by S., distant 5° from Ras Algethi.

Altair, or α Aquilæ.—E. by S. 34° from Ras Alhague, and on the edge of the Milky Way, is Altair in *Aquila*, on either side of which, in a right line, is a star of the third magnitude, that to the northward being nearer to Altair than the one to the southward.

Vega.—A line drawn north-westerly through the above three stars in Aquila to the distance of 34° from Altair, will lead to Vega in *Lyra*, one of the most brilliant stars in the northern hemisphere. Vega forms nearly an equilateral triangle with Altair and Ras Alhague.

Delphinus.—E.N.E., about 14° from Altair, are four small stars, close together, forming the figure of a diamond, or lozenge, in the constellation of *Delphinus*.

Scheat.—A line from Altair, through the diamond of Delphinus, produced to twice and a half their distance (35°), will lead to Scheat in *Pegasus*.

Alpherat.—East, 14° from Scheat, is the star Alpherat, or α in *Andromeda*. Mirach, Alpherat, and Scheat form nearly an isosceles triangle, the angle at Alpherat being very obtuse.

Algenib.—South, a little easterly, 14° from Alpherat, is the star Algenib, or γ in *Pegasus*.

Markab.—Nearly West, 17° from Algenib, and south 13° from Scheat, is the star Markab, or α in *Pegasus*. Scheat, Alpherat, Algenib, and Markab are the four stars forming what is called the *square* in Pegasus.

Fomalhaut.—A line from Scheat, through Markab, continued to about three times and a half their distance (46°), will lead to the star Fomalhaut, or α *Piscis Australis;* and the three stars come to the meridian nearly at the same time.

Fomalhaut also lies S.E. 69° from Altair in Aquila.

MAP IV. — THE PRINCIPAL STARS IN THE SOUTHERN CONSTELLATIONS.

Crux, the Southern Cross, is fully described on p. 14. A line from Sirius through η in Canis Major, and thence continued through ζ in Argo Navis for 45°, will lead to the *Southern Cross;* it also lies nearly South, distant 41° from Algoreb in Corvus.

Canopus.—Nearly South 36° from Sirius, is the star Canopus, or α in *Argo Navis*. A line from Aldebaran through Rigel, and continued to about once and three-fourths their distance (46°), will terminate three degrees to the westward of Canopus.

β Argûs Navis.—A line from α Crucis to Canopus will pass two degrees to the northward of β in *Argo Navis*, this star being nearly midway, or 20°, from the former, and 25° from the latter.

α Columbæ.—N.W. by N., 21° from Canopus, is the star α in *Columba*, to the south-eastward of which, at the distance of 3°, is β in *Columba*. The stars Rigel, Sirius, and α Columbæ form nearly an equilateral triangle.

γ Argûs Navis.—E. by N., 17° from Canopus, is γ in *Argo Navis*. This star is the middle one of three, situated in a right line, belonging to the same constellation; that to the southward, at the distance of 12°, being marked ϵ, and that to the northward, at the distance of 7°, being marked ζ.

β Centauri.—A line drawn from δ through β Crucis, produced to twice their distance (8°), will lead to β in *Centaurus;* and this line continued to once the distance of the two former stars, will terminate near α, in the same constellation.

α Pavonis.—S.E. by E., 41° from α Centauri, and S.E. by S., 51° from Antares, is the star α *Pavonis;* the three stars forming nearly an isosceles triangle.

α GRUIS.—E.N.E. 18° from α in Pavo, and S.S.W. 20° from Fomalhaut, is the star marked α *Gruis*. This star is nearly midway in a line with Fomalhaut and α Pavonis.

Fomalhaut.—N.E. by N. 20° from α Gruis, is the star Fomalhaut, or α *Piscis Australis*.

Achernar.—S.E. by E. 40° from α in Pavo is the star Achernar, or α *Eridani*. The stars α Pavonis, Fomalhaut, and Achernar form nearly an equilateral triangle.

α PHŒNICIS,—N.W. 19° from Achernar, and S.E. from Fomalhaut, is the star marked α *Phœnicis*. The three stars form nearly an isosceles triangle, the angle at α Phœnicis being very obtuse.

Lunar Distance Stars.—The nine fixed stars known as *lunar distance stars*, are α Arietis, Aldebaran (α Tauri), Pollux (β Geminorum), Regulus (α Leonis), Spica (α Virginis), Antares (α Scorpii), α Aquilæ (Altair), Fomalhaut (α Piscis Australis), and α Pegasi (Markab.)

These are the brightest stars lying near the moon's path, and when within range are tabulated in the *Nautical Almanac* for every three hours of Greenwich mean solar time.

Long before the Lunar Tables had acquired the exactness they have at present, the method of determining the longitude by observing the distance between the moon and a star occupied the attention of astronomers. Werner of Nuremberg wrote on the subject in 1514, and Gemma Frisius in 1545. Kepler, in his Rudolphine Tables, discusses the utility of this method of finding the longitude at sea; and Christian Longomontanus, in 1622, gave the following catalogue of stars with which the moon was to be observed, viz., α Arietis, Aldebaran, ζ Tauri, Propus, Pollux, δ Cancri, Regulus, β Virginis, Spica Virginis, α Libræ, β Scorpii, ξ Sagittarii, β Capricorni, δ Capricorni, and λ Aquarii.

ON THE USE OF TABLE 1.

This table gives the mean places (*Right Ascension* and *Declination*) of the principal fixed stars for January 1, 1877; for any other date you can find the approximate mean place of a star by the "annual variation." If you want the R.A. and Decl. of α Bootis (Arcturus) on Jan. 1, 1879, since two years have elapsed since 1877, then $2{\cdot}734 \times 2 = 5^{s}{\cdot}468$ to be added to $14^{h}\ 10^{m}\ 3^{s}{\cdot}098$ gives $14^{h}\ 10^{m}\ 8^{s}{\cdot}566$ as the R.A. for 1879; and $18{\cdot}839 \times 2 = 37''{\cdot}678$ to be subtracted from $19°\ 49'\ 25''{\cdot}98$ gives $19°\ 48'\ 48''{\cdot}30$ as the Decl. for 1879. You can also by the "annual variation" make the correction for any proportionate part of a year.

ON THE USE OF TABLE II.

This table gives, for the first day of every month, the "*mean times of transit of the principal fixed stars*," that is, the mean time at which any particular star passes the meridian,—but for *circumpolar* stars the time of transit when *above the pole;* it is only approximate, but sufficiently correct for ordinary purposes. It is also astronomical, not civil, time.

You intend to examine the heavens when SIRIUS is on the meridian on January 1st.; you turn to Table II. and find the time to be $11^{h}\ 53^{m}$ P.M. But as a star comes to the meridian 4 minutes later every successive day, then, for 15 days you have $4^{m} \times 15 = 60^{m}$ or 1 hour; and consequently $10^{h}\ 53^{m}$ P.M. will be the time of SIRIUS coming to the meridian on Jan. 16th.

When using the Table do not forget that if the time exceeds 12 hours, you must, for civil date, advance the day by one and take 12 from the hours; thus, the Table says SIRIUS passes the meridian on November 1st, at $15^{h}\ 58^{m}$, consequently that is at $3^{h}\ 58^{m}$ A.M. on November 2nd. In fact, whenever you find that the time exceeds 12 hours, the meridian passage occurs at some period between midnight and noon, or during A.M.; where the time is less than 12 hours, it is P.M.

RIGEL in Orion passes the meridian on Oct. 1d. $16^{h}\ 25^{m}$, that is on Oct. 2nd at $4^{h}\ 25^{m}$ A.M.; for 20 days later you have $4 \times 20 = 80^{m} = 1^{h}\ 20^{m}$ to subtract from $16^{h}\ 25^{m}$, giving Oct. 21d. $15^{h}\ 5^{m}$ as the astronomical time, or Oct. 22nd. $3^{h}\ 5^{m}$ A.M. civil time.

α Cassiopeiæ passes the meridian above the pole on Jan. 1, at $5^{h}\ 48^{m}$ P.M.; at *about* the same hour A.M. it will be below the pole, being *circumpolar* to our latitude. On April 3rd it passes the meridian above the pole at about midday ($23^{h}\ 58^{m}$); it will be visible below the pole at midnight.

EXPLANATION OF TERMS—GEOGRAPHICAL AND ASTRONOMICAL:—AND ON THE USE OF THE STAR-MAPS.

It will be necessary to explain a few terms, before describing the use of the Maps, and showing how to distinguish the Stars.

1. The *Elevated Pole* is the pole of the observer's hemisphere; hence in north latitude it is the N. pole of the heavens, in south latitude it is the S. pole; and the elevation of the pole is equal to the latitude; if your latitude is 50° the pole is elevated 50° above the horizon; if the lat. is 30°, that is also the elevation of the pole.

2. In whatever part of the world you are the *Zenith* is the point *directly over head*, and hence you always carry your Zenith with you.

3. From the Zenith to the Horizon is *about* 90°; more or less according to the character of the boundary of your vision. If, in the direction in which you look, the ground is higher than that where you stand it will be less; otherwise it may be slightly more; at sea, raised on the deck of a

vessel, it will always be more. Roughly, and under ordinary circumstances, it may be taken as 90°, and this fact will enable you to estimate (approximately) the altitude of the stars you are observing; midway from the horizon to the zenith will be 45°, one-third upward 30°, two-thirds 60°, and so forth. The cardinal points of the horizon are the *true* North and South through which trends the meridian of the place where you are, and the *true* East and West through which trends your prime vertical, concerning both of which you must next be informed. You should learn the points of the compass.

4. Standing on a spot in the northern hemisphere, if you look to the true South point of the horizon, the zenith is overhead, and the true North point of the horizon will be at your back; if you look to the true North point, the true South point will be at your back. Your *meridian will be the great circle extending from the true North point of the horizon, through the N. pole of the heavens, through the zenith, and thence to the true South point of the horizon;* it extends also through the S. pole, but this you do not see: such a circle is perpendicular to the equator.

In general terms, the Meridian is a great circle passing through both poles, and perpendicular to the equator. To an observer in either hemisphere it is the imaginary circle passing through the elevated pole, through the zenith, and reaching the horizon in the true N. and S. points. But if you are on the equator, then you will see both poles; hence the N. pole will coincide with the true N. point of the horizon, and the S. pole with the true S. point of the horizon; and your zenith (the point over head) will be on the equinoctial, or celestial equator.

You ought to settle (approximately) the position of your meridian before you commence the study of the stars.

If you already know the Pole Star by means of the Pointers in the Great Bear, you can readily find the direction of your meridian. Polaris, or the Pole Star, in the Little Bear, is never more than $1\frac{1}{3}°$ from the pole. You will see it on Map I, and also on the outside of the cover of this book;* and there are explanations on p. 12-13 for finding it. On turning to Table II. you will see that *α* Ursæ Minoris (Polaris) is the sixth star in the column, and that under Jan. 1, it *transits*, or passes the meridian, at about $6^h\ 19^m$ P.M. Let us say that (having provided yourself with two or three straight sticks, four to six feet long) you go into your garden at or a little before half-past 6 P.M.; you make out the Pole Star, and set up one of the sticks as upright as possible; then, move away from this stick in a direction such that the Pole Star shows in a line with the stick, but beyond it; at a convenient distance set up a second stick, as upright as possible, in a line with the first stick and the Pole Star. The two sticks and the Pole Star in line show you the direction of your meridian. A third stick exactly in a line between the two might then be advantageously set up. Standing at the first stick, and looking towards the other two, you would be facing the true S. point of the horizon; standing at one of the other sticks, and looking towards the Pole Star, you would be facing the true N. point of the horizon; and the vertical circle trending upwards from either of those points of the horizon, passing through the zenith and pole would be your meridian.

You may verify the direction of this line by the mariner's compass, if you have one.*

5. You now know the direction of your meridian; and the next thing to find is the *direction of the Prime Vertical.* The prime vertical is the great circle at right angles to the meridian: hence it passes through the zenith and cuts the horizon at the *true* East and West points. Reverting to our sticks, if you stand in the line of the meridian, facing the true North, on extending your arms to the level of the shoulders, the right hand will point to the East, and the left hand to the West; but facing the south, the right hand will point West, and the left East. In connection with these remarks you can also refer to the *note* below.

6. You know that Latitude fixes your position in respect to the Equator, as when you say that London is in Lat. $51\frac{1}{2}°$ North, you mean that London is $51\frac{1}{2}°$ distant *from the Equator* in a direction towards the North pole of the earth. But when speaking of any celestial body, the term in respect to it that answers to geographical latitude is *Declination.* The great circle from which declination is reckoned is the *Equinoctial* or celestial equator, which is an extension of the plane of the terrestrial equator to the celestial concave; and it is further reckoned North or South (as the case may be) towards the celestial poles, which are 90° from the equinoctial. On Map II, "Zodiacal Constellations," the straight line that runs across it (in the middle) from right to left represents the equinoctial; you will see that the lines on each side of the map are perpendicular to the equinoctial, and are graduated (marked) in tens upwards and downwards, with small strokes between the tens; the distance between each small stroke is a degree of declination; as in ordinary maps the top is North, and the bottom South, and the equinoctial is, in this map, the dividing line. Now, if you measure the vertical distance from the equinoctial to Regulus in Leo, and refer it to the

* At about $5^h\ 17^m$ P.M. on Jan. 1st, if you look to the north, the heavens will have very much the aspect presented by the plate on the front cover of the book. If you refer to Map I, turning it upside down, so that I (near the word "Andromeda") shall then be at the top, and XIII at the bottom, a piece of thread stretched from I to XIII will be the right ascension of your meridiam at about $6^h\ 30^m$, and you will see it passes through the Pole Star.

* You should have a small pocket compass from two to three inches in diameter; it would be useful in showing the direction of any of the heavenly bodies at any time. In respect to what has been said above about the direction of the meridian, your meridional line, if you are in the vicinity of London, where the *variation of the compass* is 19° West, would trend N. 19° E. and S. 19° W. by compass indication. It would be better to have a compass in which the magnetic needle is freely suspended on its pivot, and the compass card pasted on the bottom of the box; then, as the variation of the compass is in some parts of the world West, and in other parts East, proceed as follows: where the variation is W. let the N. end of the needle come to rest on the number of degrees of variation west of north, if the variation is E. let the N. end of the needle come to rest on the number of degrees east of north,—then, in each case, the line of the compass card below, extending from N. to S. will be in the meridian, and that extending from E. to W. will be in the prime vertical; and all the points of the compass card will be *true.* Take care that the compass is steady and away from all iron. Using such a compass in the vicinity of London, you bring the N. end of the needle to rest 19 degrees west of north; where the variation is 21° W., bring it to rest 21° west of north; if the variation is 10° E. bring the N. end of the needle to rest 10° east of north. The compass card below the needle then indicates the *true* points of the horizon.

graduated line at either side, you will read off that star's declination as 12½° N., because it is that distance north of the equinoctial; similarly measured, Pollux has its declination 28⅓° N., and Sirius 16½° S.

The same remarks apply to Map III.

It is hoped you now know the meaning of declination, and, no doubt, you can understand that, since it corresponds to geographical latitude, any star whose declination is equal to, and of the same name as, the latitude must, at some period of its revolution in the 24 hours, pass directly over head.

7. In like manner as Longitude determines the position of a place reckoned from some fixed meridian, so is *Right Ascension* its equivalent in respect to a celestial body; but there is this difference between the two terms, that while geographical longitude may be east or west up to 180°, right ascension, which commences at the First Point of Aries as its fixed meridian, is reckoned in only one direction, through 360°, or 24 hours; and it is mostly customary to express it in hours, minutes and seconds. If you look to Map II. you will see the top and bottom lines marked in roman numerals from O to XII., and Map III from XII to XXIV.; these are hours of right ascension, and each of the intervening short spaces indicates 5 minutes: you will also see that O hour commences at a spot in the equinoctial under Pisces, for a reason which is explained on p. 17. You have already determined the position of Regulus (in Leo) as regards declination; by measuring its distance from the nearest line at the side of the map, and referring this distance to the top line of Map II., which is marked in hours, you will read the right ascension of Regulus as 10h. nearly; similarly, the right ascension of Pollux is 7h. 40m., and that of Sirius 6h. 40m.

Thus the Right Ascension and Declination of a Star fix its exact position in the celestial concave, as Latitude and Longitude fix the exact position of a spot on the globe. Right Ascension is reckoned Eastward *along* the equinoctial from the First Point of Aries, through 24 hours; and the *circles* of right ascension are supposed to move with the stars. Declination is reckoned *from* the equinoctial, N. or S. towards the poles.

Right Ascension is usually abbreviated to R.A.

8. It may also be noted here that while it is customary to speak of the distance of a place from the pole as its *co*-latitude,* *polar distance* is the term used to express the *distance of a star from the pole;* and reference is most frequently made to the *elevated pole*, that is, the pole of the hemisphere in which the observer is placed. For the co-lat. of London we have 38½°, *i.e.* 90° less the lat.; similarly the North polar distance of Pollux is 61⅔°, *i.e.* 90° less its dec. (28⅓° N.); and the N. pol. dist. of Sirius is 106½°, *i.e.* 90° *plus* the dec. (16½° S.). But for a place in lat. 40° S., the co-lat. of which is 50°, the S. pol. dist. of Sirius is 73½°, and the S. pol. dist. of Pollux 118⅓°.

9. The *Hour-angle* of a star is the angular distance of the star's circle of right ascension from the meridian of the observer, measured on the equator in hours, minutes, and seconds.

* *Co* is the abbreviation of *complement*, hence co-lat. means the complement of the latitude; it is obtained by subtracting the latitude from 90°; thus, if your latitude is 53°, the co-lat. is 37°.

CATALOGUE OF STARS ARRANGED IN THE ORDER OF THEIR DECLINATION FROM NORTH TO SOUTH.

α	Ursæ Minoris (*Polaris*)	N 88°·7
β	Ursæ Minoris (*Kochab*)	74·7
β^2	Cephei	70·0
α	Ursæ Majoris (*Dubhe*)	62·4
α	Cephei (*Alderamin*)	62·1
η^2	Draconis	61·8
α	Cassiopeiæ	55·9
γ	Ursæ Majoris	54·4
β	Draconis	53·4
θ	Ursæ Majoris	52·2
γ	Draconis	51·5
η	Ursæ Majoris (*Benetnasch*)	49·9
α	Persei (*Mirfak*)	49·4
ι	Ursæ Majoris	48·5
α	Aurigæ (*Capella*)	45·9
α	Cygni	44·8
α	Canum Venaticorum	39·0
α	Lyræ (*Vega*)	38·7
ι	Aurigæ	33·0
α^2	Geminorum (*Castor*)	32·2
ζ	Herculis	31·8
ζ	Cygni	29·7
β	Tauri	28·5
α	Andromedæ (*Alpherat*)	28·4
β	Geminorum (*Pollux*)	28·3
ε^2	Bootis	27·6
α	Coronæ (*Alphacca*)	27·1
ε	Leonis	24·3
η	Tauri	23·7
α	Arietis (*Hamel*)	22·9
δ	Leonis	21·2
γ^1	Leonis	20·5
β	Arietis	20·2
α	Bootis (*Arcturus*)	19·8
η	Bootis	19·0
γ	Geminorum	16·5
α	Tauri (*Aldebaran*)	16·3
β	Leonis (*Denebola*)	15·3
α	Pegasi (*Markab*)	14·5
α^1	Herculis	14·5
γ	Pegasi (*Algenib*)	14·5
ζ	Aquilæ	13·7
α	Ophiuchi	12·7
α	Leonis (*Regulus*)	12·6
γ	Aquilæ	10·3
ε	Pegasi	9·3
α	Aquilæ (*Altair*)	8·5
α	Orionis (*Betelgeux*)	7·4
α	Serpentis (*Unuk*)	6·8
ω	Piscium	6·2
α	Canis Minoris (*Procyon*)	5·5
α	Ceti (*Menkar*)	N 3·6
η	Virginis	0·0
δ	Orionis	S 0·4
γ	Virginis	0·8
α	Aquarii	0·9
ε	Orionis	1·3
δ	Ophiuchi	3·4
β	Aquarii	6·1
α	Hydræ (*Alphard*)	8·1
β	Orionis (*Rigel*)	8·3
β	Libræ	8·9
α	Virginis (*Spica*)	10·5
α^2	Capricorni	12·9
γ^1	Eridani	13·9
δ	Crateris	14·1
α	Libræ	15·5
α	Canis Majoris (*Sirius*)	16·5
α	Leporis	17·9
β	Ceti	18·7
β^1	Scorpii	19·6
μ	Sagittarii	21·1
β	Corvi	22·7
15	Argûs (Navis)	24·0
α	Scorpii (*Antares*)	26·2
ε	Canis Majoris	28·8
α	Piscis Australis (*Fomalhaut*)	30·3
α	Columbæ	34·1
α	Gruis	47·6
α	Argûs (*Canopus*)	52·6
α	Pavonis	57·1
α	Eridani (*Achernar*)	57·9
ι	Argûs	58·8
η	Argûs	59·0
β	Centauri	59·8
α^2	Centauri	60·3
α^1	Crucis	62·4
α	Trianguli Australis	68·8
β	Hydri	77·9
σ	Octantis	S. 89·3

With regard to an observer's position in either hemisphere the whole heavens may be divided into three parts:—1. A part which is never below the horizon; 2. A part which rises and sets; 3. A part which never rises above the horizon. I shall *first* use the *polar distances of the stars* to illustrate these facts, because it is the more usual method.

I have arranged a catalogue of the stars of the first, second and third magnitudes in the order of their declination (*see* p.27), so that you may understand, for any given place on the earth's surface, the ranges of their visibility; but you must clearly recognise the fact that even of those that do come within that range, some will be visible at one hour, others at another hour, some at one season, others at another season, for they will rise, culminate, and set in the order of their right ascension, and relatively according to the right ascension of your meridian.

1. *No star can set if its polar distance is less than the latitude* of the observer's position. Hence, for the latitude of London, $51\frac{1}{2}°$ N., all the stars in the upper part of the catalogue, as far as *Vega* in Lyra never set; the pol. dist. (90° less the dec.) of all of them being less than $51\frac{1}{2}°$ they are *circumpolar*, and it is to be observed that all such stars pass the meridian twice in 24 hours,—once above, and once below, the pole. Map I. *The North Polar Constellations*, and Maps II. and III. as far as declination $38\frac{1}{2}°$ N., show the part of the heavens that is never below the horizon of London.

2. Of the stars just indicated, some of them, at some hour of the day or night, must pass across the zenith, *i.e.*, directly over head; *any star whose polar distance is exactly the same as the co-latitude* will do so. Now the co-latitude of London is 90° less $51\frac{1}{2}° = 38\frac{1}{2}°$; and the polar distance of γ Draconis, in the catalogue, is $38\frac{1}{2}°$ since its declination is $51\frac{1}{2}°$; therefore this star must, at some hour, be on the zenith of London. If you wish to know what other stars will pass the zenith, refer to Map 1., take a pair of dividers (compasses), put one leg in the pole (where the two straight lines cross each other), extend the other leg to the star Etanim or γ in Draco, with this distance describe a circle round the pole, and any star on that circle will cross the zenith: the circle passes through the head of Draco, and its two conspicuous stars γ and β,—also close to η and θ in Ursa Major,—through the head of Auriga,—and close to γ in the head of Perseus.

3. It is to be noted that all the stars within the circle you have just described (and consequently all above γ Draconis, in the catalogue), *never come to the prime vertical, because* their *polar distance is less than the co-latitude;* when they pass the meridian above the pole they do so between the zenith and the pole; when they pass the meridian below the pole they do so between the pole and the North point of the horizon.

Of the other stars that pass the meridian twice in 24 hours, those exterior to the circle you described, and that lie between γ in Draco and *Vega* in Lyra, will, when they pass the meridian below the pole, do so between the pole and the North point of the horizon; but as their polar distance is greater than the co-latitude, they will pass the prime vertical in their revolution, and come to the meridian above the pole when between the zenith and the South point of the horizon.

4. It remains to show how many of the stars in this catalogue below Vega in Lyra can be seen in the latitude of London. *No star can be visible if its polar distance exceeds* 90° *added to the co-latitude of a place;* the co-latitude of London being $38\frac{1}{2}°$, add 90° and you get $128\frac{1}{2}°$; casting your eyes down the catalogue you will see that the distance of α Columbæ from the elevated (N.) pole is 90° + 34° = 124°; similarly the polar distance of α Gruis is 137°, and consequently beyond the range of your vision; therefore you can see no bright star of the catalogue beyond α Columbæ. You can put the range of visibility into the other hemisphere in another form; you can see no star the declination of which is greater than the co-latitude,—the declination differing in name from the latitude: α Columbæ nearly answers this.

Thus then, in the latitude of London, at some time of the 24 hours, and according to the season, some or other of the stars between Polaris and α Columbæ will be visible; all those in the catalogue, from Polaris to Vega in Lyra, with Dec. exceeding $38\frac{1}{2}°$ N., are *circumpolar*, being never below the horizon; all those below α Columbæ, with Dec. exceeding $38\frac{1}{2}°$ S., are never seen, for they never rise to the horizon; and all those from Vega in Lyra to α Columbæ, with Dec. less than $38\frac{1}{2}°$ N. and $38\frac{1}{2}°$ S. rise and set alternately.

What has already been said may be put in another, and (to some) in a simpler, form,—using the terms *Declination* of a star, *Latitude* of a place—and hence its *co-latitude*:—

(*a*). With Dec. and Lat. of the same name, both N. or both S., if the Dec. be *greater* than the co-lat., such stars are never below the horizon of the observer, and are called *circumpolar* stars.

Ex.—In Lat. 56° N., and hence co-lat. 34°, all stars having greater Dec. than 34° N. never set, and appear to revolve round the N. pole of the heavens.

Ex.—In Lat. 42° S., and hence co-lat. 48°, all stars having greater Dec. than 48° S., never set, and appear to revolve round the S. pole of the heavens.

(*b.*) With Dec. and Lat. of different names, one N. and the other S., if the Dec. be *greater* than the co-lat., such stars are never above the horizon of the observer.

Ex.—In Lat. 52° N., and hence co-lat. 38°, all stars having greater Dec. than 38° S. never rise above the horizon.

Ex.—In Lat. 40° S., and hence co-lat. 50°., all stars having greater Dec. that 50° N. never rise above the horizon.

(*c.*) With Dec. and Lat. of the same name, if the Dec. is *equal* to the Lat., such stars cross the zenith of the observer.

Ex.—In lat. 50° N., all stars having Dec. 50° N., pass directly over head, in the zenith.

Ex.—In Lat. 44° S., all stars having Dec. 44° S. pass directly over head, in the zenith.

(*d.*) Whether Dec. and Lat. are of the same or different names, all stars having Dec. *less* than the co-lat. rise and set alternately.

Ex.—In Lat. $51\frac{1}{2}°$ N., and hence co-lat. $38\frac{1}{2}°$, all stars having less Dec. than $38\frac{1}{2}°$ N. or $38\frac{1}{2}°$ S., or that range between Dec. $38\frac{1}{2}°$ N. and Dec. $38\frac{1}{2}°$ S., rise and set alternately.

Ex.—In Lat. 44° S, and hence co-lat. 46°, all stars that range between Dec. 46° S. and Dec. 46° N. rise and set alternately.

Of the Stars that rise and set, how long are they above the horizon?

(1.) When the polar distance is 90°,—or what is the same thing, when the declination is 0°,—the star rises in the East point of the horizon, and sets in the West point; that is, it rises and sets where the prime vertical meets the horizon; but owing to the effect of refraction, the tendency of which is to make an object appear higher than it really is, the star is seen raised on the prime vertical to the extent of rather more than half a degree when in the horizon. The hour-angle of such a star at rising and setting is 6 hours; that is, from the time of rising to the time of being on the meridian is 6 hours, and similarly from the time of being on the meridian to the time of setting is another 6 hours; so that it is 12 hours above the horizon, and 12 hours below it.

(2.) When the polar distance is less than 90°, as is the case when the latitude of the observer and the declination of the star have the same name, N. or S., the star rises and sets on the same side of the East and West points as the elevated pole; hence in north latitude it rises north of east, and sets north of west; in south latitude it rises south of east and sets south of west; such a star passes the prime vertical twice; its hour-angle at rising and setting is greater than 6 hours, consequently it is more than 12 hours above the horizon, and less than 12 hours below it.

(3.) When the polar distance exceeds 90°, as is the case when the latitude of the observer and the declination of the star have different names, one N. and the other S., the star rises and sets on that side of the East and West points which is farthest from the elevated pole; such a star never comes to the prime vertical above the horizon; its hour-angle at rising and setting is less than 6 hours, consequently it is less than 12 hours above the horizon, and more than 12 hours below it.

How to use Maps I., II. *and* III. *being situated in the Northern Hemisphere;*—let us take any part of Great Britain or Ireland.

From what has been said on p. 26 you know the direction of your meridian, and that, when facing North, you have East to the right and West to the left; but when facing South, you have East to your left, and West to your right.

To use Map I. you must face North. To use Maps II. and III. you must face South, in order to recognise the face of the heavens as depicted on them; you will generally have to join Map III. to Map II.; do so by placing each Map side by side at XII., in which case Map II. will be to the right of III.;—or by placing XXIV. over O., in which case Map III. will be to the right of II.; you will do either as required.

(A.) When Orion is on the meridian, as between 8 and 9 P.M. on Feb. 1st (*see* Tab. II., p. 32), then, by Map II., looking South to Orion you will have Taurus, Aries, Cetus, &c., to the westward (on the *right*), and Gemini, Canis Minor, Canis Major, Leo, &c., to the eastward (on the *left*). Auriga will be over head.

(B.) At the same time as Orion is on the meridian, you will see, at top of Map II. that the R.A. of the meridian is between V. and VI.; to use Map I. at that time, face North, placing V.–VI. uppermost, and XVII.–XVIII h. downwards; you will see Auriga above the pole, and Ursa Minor and Draco below the pole.

(C.) When Lyra is on the meridian, as between 9 and 10 P.M. in August (*see* Tab. II.), then by Map III., looking S. to Lyra, you will have Hercules, Ophiucus, Serpens, Scorpio, Bootes, Virgo, &c., to the west; and Aquila, Capricornus, Pegasus, &c., to the east.

(D.) When Lyra is on the meridian, by Map I. you will see on facing N., and turning XVIII.–XIX h. (the R. A. of Lyra) uppermost, that Draco is above the pole, and Auriga below it.

(E.) When Virgo is on the meridian (as at 10h. P.M. in May), join Maps II. and III. at XII h.; then Leo, Hydra, Gemini, Canis Minor, Canis Major, &c. will be to the westward; and Bootes, Serpens, Hercules, Ophiucus, Scorpio, &c. to the eastward. By Map I., with XIII h. uppermost, the tail of Ursa Major will be overhead; while the tail of Draco, and Ursa Minor will be above the pole, and Cassiopeia below the pole.

(F.) When Pegasus is on the meridian, as from 8 to 9 P.M. in Nov., join Maps III. and II. at XXIV. and O.; then Aquila, Capricornus, Lyra, &c. will be to westward; and Aries, Cetus, Taurus, Orion, &c. to eastward. By Map I. with XXIV.–I h. uppermost, Cassiopiœa will be overhead, and the tail of Ursa Major below the pole.

Unless you know how to find the Right Ascension of your meridian,* use Tab. II. p. 32–35 in connection with the Maps of the Stars. At any hour you intend to look to the heavens, under the month find the given hour; then see what star or constellation is on the meridian; turn to the map that gives that constellation, and use the map or maps as you have already done in following paragraphs A, B, C, D, E, and F.

You will see that the Stars, in Table I. p. 30–31, *are given in the order of their Right Ascension from* 0 *to* 24 *hours; they pass the meridian of a place in this order, those with less R A. before those with greater; thus* ALDEBARAN *in Taurus whose R.A. is* $4^{h.}\ 29^{m.}$ *will pass the meridian* $2^{h.}\ 11^{m.}$ *before* SIRIUS *in Canis Major whose R.A. is* $6^{h.}\ 40^{m.}$

It is to be noted that when any given star is on the meridian of a place, those with less R A. than that particular star will be West of the meridian, and those with greater R.A. will be East of the meridian. Thus, when REGULUS in Leo (whose R.A. is $10^{h.}\ 2^{m.}$) is on the meridian, those stars with less R. A., as POLLUX, PROCYON, CASTOR, RIGEL, ALDEBARAN, &c., will be West of (and past) the meridian, and some will be setting; those with greater R.A., as SPICA, ARCTURUS, &c., will be East of (and coming to) the meridian, in their respective order.

Also note, that when the R.A. of a star is small, and it is on the meridian, then those with greater R.A. will be East of the meridian, as before mentioned; and those with less R.A. will be West of the meridian; but with the latter will be included some stars whose R.A. is greater than 12 *hours.*

For example, when α Arietis (whose R.A. is $2^{h.}$) is on the meridian, then those with greater R.A., as ALDEBARAN, RIGEL, BETELGEUX, CASTOR, PROCYON, POLLUX, &c, will be East of (and coming to) the meridian; those with less R.A., as ALGENIB, ALPHERAT, &c., will be West of the meridian; but further westward will also be MARKAB (whose R A. is $22^{h.}\ 58^{m.}$), ALTAIR (whose R.A. is $19^{h.}\ 45^{m.}$), &c., &c. This will be understood from what has been already said.

If you are in the *Southern Hemisphere*, Map. IV. will give most of the circumpolar stars. Maps II. and III. will give the over-head stars, and those to the northward, but to recognise the features of the heavens you must turn these maps *bottom upwards*,—when E. will be to the right, and W. to the left.

* The R.A. of the meridian is found by taken the sum of the *mean time* at place and the sidereal time for the given day, rejecting 24 hours when the sum exceeds 24h.; then, any stars with R.A. equal to your R.A. will be on the meridian. The sidereal time is given in most sixpenny seaman's almanacs.

MEAN PLACES OF STARS.

FOR JANUARY 1st, (Noon) 1877.

Star's Name.	Mag.	Right Ascension.	Annual Var.	Declination.	Annual Var.
		h m s	s	° ′ ″	″
α Andromedæ ... (*Alpherat*)	2	0 2 1·904	+ 3·0878	N 28 24 40·57	+19·903
γ Pegasi ... ... (ALGENIB)	3.2	0 6 54·181	+ 3·0827	N 14 29 58·06	+20·025
β Hydri	3	0 19 15·865	+ 3·2730	S 77 56 52·68	−20·245
α Cassiopeiæ ... (*Schedir*) (var.) ...	2.3	0 33 32·198	+ 3·3660	N 55 51 44·71	+19·799
β Ceti ...(*Deneb Kaitos*)	2	0 37 24·801	+ 3·0119	S 18 39 43·87	−19·806
ε Piscium	4	0 56 33·676	+ 3·1117	N 7 13 38·17	+19·446
α Ursæ Minoris ... (POLARIS)	2	1 13 40·939	+21·1626	N 88 39 11·89	+19·023
θ Ceti	3	1 17 52·463	+ 2·9962	S 8 49 6·80	−18·686
η Piscium	4.3	1 24 54·149	+ 3·1995	N 14 42 40·04	+18·692
α Eridani ... (ACHERNAR)	1	1 33 7·667	+ 2·2339	S 57 51 42·61	−18·409
β Arietis ... (*Sheratan*)	3.2	1 47 50·749	+ 3·2975	N 20 12 21·13	+17·764
α Arietis ... (*Hamel*)	2	2 0 14·489	+ 3·3670	N 22 52 47·29	+17·206
ξ² Ceti	4	2 21 37·188	+ 3·1809	N 7 54 27·23	+16·324
γ² Ceti	3.4	2 36 55·660	+ 3·1014	N 2 42 57·76	+15·342
α Ceti ... ... (*Menkar*)	2.3	2 55 51·005	+ 3·1288	N 3 36 21·20	+14·324
α Persei ... ... (*Mirfak*)	2	3 15 32·907	+ 4·2507	N 49 25 17·31	+13·135
ε Eridani	3	3 27 8·143	+ 2·8224	S 9 52 33·99	−12·363
η Tauri ... . . (*Alcyone*)	3	3 40 10·462	+ 3·5529	N 23 43 23·03	+11·428
γ¹ Eridani ... (*Zaurac*)	3	3 52 17·396	+ 2·7943	S 13 51 35·74	−10·484
ε Tauri	4.3	4 21 26·081	+ 3·4935	N 18 54 20·82	+ 8·330
α Tauri ... ... (ALDEBARAN)	1	4 28 51·823	+ 3·4359	N 16 15 36·80	+ 7·594
ι Aurigæ	3	4 48 59·067	+ 3·8953	N 32 58 9·19	+ 6·092
ε Leporis	4.3	5 0 15·212	+ 2·5363	S 22 32 16·40	− 5·097
α Aurigæ ... (CAPELLA)	1	5 7 36·282	+ 4·4229	N 45 52 13·47	+ 4·112
β Orionis ... (RIGEL)	1	5 8 37·586	+ 2·8801	S 8 20 43·86	− 4·436
ζ Tauri ... ...(*Natli*)	2	5 18 31·078	+ 3·7895	N 28 30 4·67	+ 3·408
δ Orionis ... (*Mintaka*)	2	5 25 43·387	+ 3 0643	S 0 23 31·25	− 2·946
α Leporis ... (*Arneb*)	3	5 27 18·331	+ 2·6456	S 17 54 42·58	− 2·849
ε Orionis ... (*Alnilam*)	2	5 29 58·285	+ 3·0406	S 1 16 56·09	− 2·608
α Columbæ ... (*Phact*)	2	5 35 11·830	+ 2·1791	S 34 8 25·52	− 2·165
α Orionis ... (*Betelgeux*) (var.) ...	1	5 48 30·773	+ 3·2463	N 7 22 55·76	+ 1·002
μ Geminorum	3	6 15 31·172	+ 3·6319	N 22 34 28·22	− 1·499
α Argûs ... ... (CANOPUS)	1	6 21 13·395	+ 1·3304	S 52 37 44·98	+ 1·855
γ Geminorum ... (*Alhena*)	2.3	6 30 36·332	+ 3·4659	N 16 30 8·45	− 2·713
α Canis Majoris ... (SIRIUS)	1	6 39 43·642	+ 2·6461	S 16 32 55·55	+ 4·702
ε Canis Majoris	2.1	6 53 47·521	+ 2·3572	S 28 48 21·54	+ 4·685
δ Geminorum ... (*Wesat*)	3.4	7 12 46·614	+ 3·5907	N 22 12 24·63	− 6·284
α² Geminorum ... (CASTOR)	2.1	7 26 45·033	+ 3·8402	N 32 9 22·80	− 7·494
α Canis Minoris (PROCYON)	1	7 32 51·786	+ 3·1435	N 5 32 18·05	− 8·988
β Geminorum ... (POLLUX)	1.2	7 37 47·244	+ 3·6791	N 28 19 17·38	− 8·363
6 Caneri	5	7 55 57·657	+ 3·6926	N 28 8 14·45	− 9·792
15 Argûs (Navis)	3	8 2 18·356	+ 2·5540	S 23 57 3·46	+10·144
ε Hydræ...	3.4	8 40 15·683	+ 3·1825	N 6 52 7·49	−12·950
ι Ursæ Majoris ... (*Talitha*)	3	8 50 46·720	+ 4·1366	N 48 31 22·79	−13·882
ι Argûs	2	9 13 47·758	+ 1·6015	S 58 45 31·56	+14·938
α Hydræ (*Alphard* or *Cor Hydræ*)	2	9 21 32·534	+ 2·9465	S 8 7 35·53	+15·420
θ Ursæ Majoris	3	9 24 37·155	+ 4·0435	N 52 14 11·20	−16·193
ε Leonis...	3	9 38 52·046	+ 3·4176	N 24 20 22·18	−16·392
α Leonis... ... (REGULUS)	1.2	10 1 49·199	+ 3·2002	N 12 34 3·31	−17·438
γ¹ Leonis... ... (*Algeiba*)	2	10 13 11·334	+ 3·3154	N 20 27 46·49	−18·067
ρ Leonis...	4	10 26 20·044	+ 3·1654	N 9 56 18·89	−18·434
η Argûs ... ... (var.) ...	1.6	10 40 17·530	+ 2·3108	S 59 2 14·05	+18·762
α Ursæ Majoris ... (*Dubhe*)	2	10 56 7·425	+ 3·7587	N 62 24 51·81	−19·372
ζ Leonis ... ... (*Zosma*)	2.3	11 7 33·934	+ 3·2008	N 21 11 49·92	−19·672
δ Crateris	3.4	11 13 11·517	+ 2·9951	S 14 6 47·67	+19·458
β Leonis ... (*Denebola*)	2	11 42 47·073	+ 3·0636	N 15 15 34·38	−20·098
γ Ursæ Majoris (*Megrez*)	2.3	11 47 21·288	+ 3·1860	N 54 22 42·42	−20·024
ε Corvi	3	12 3 48·065	+ 3·0763	S 21 56 8·13	+20·041
β Chamæleontis...	5	12 11 9·354	+ 3·3516	S 78 37 46·25	+20·039
η Virginis	3.4	12 13 36·745	+ 3·0652	N 0 1 0·72	−20·049
α¹ Crucis	1	12 19 45·570	+ 3·2697	S 62 24 57·68	+19·929

MEAN PLACES OF STARS.

FOR JANUARY 1st, (Noon) 1877.

Star's Name.	Mag.	Right Ascension.	Annual Var.	Declination.	Annual Var.
		h m s	s	° ′ ″	″
β Corvi ... ... (*Albireo*)	2.3	12 27 55·565	+ 3·1323	S 22 42 58·97	+19·975
γ Virginis ... ... (mean)	3.2	12 35 25·717	+ 3·0381	S 0 46 29·65	+19·865
α Canum Venaticorum (*Cor Caroli*)	3	12 50 16·287	+ 2·8137	N 38 58 59·03	−19·513
α Virginis ... (Spica)	1	13 18 42·818	+ 3·1509	S 10 31 7·42	+18·922
ζ Virginis	3.4	13 28 25·592	+ 3·0530	N 0 2 1·30	−18·519
η Ursæ Majoris ... (*Benetnasch*)	2	13 42 41·604	+ 2·3717	N 49 55 39·20	−18·103
η Bootis ... ... (*Muphrid*)	3	13 48 49·710	+ 2·8576	N 19 0 54·00	−18·194
β Centauri	1	13 55 9·406	+ 4·1676	S 59 46 43·19	+17·644
α Bootis ... ... (Arcturus)	1	14 10 3·098	+ 2·7340	N 19 49 25·98	−18·839
ρ Bootis	4.3	14 26 31·755	+ 2·5866	N 30 54 43·95	−15·952
α^2 Centauri	1	14 31 16·600	+ 4·0428	S 60 19 24·20	+14·994
ϵ^2 Bootis ... ... (*Mirac*)	2.3	14 39 36·913	+ 2·6190	N 27 35 37·17	−15·373
α Libræ (*Zuben-el-Chamali*)	2.3	14 44 4·542	+ 3·3092	S 15 31 46·12	+15·190
β Ursæ Minoris (*Kochab*)	2	14 51 4·901	− 0·2412	N 74 39 28·66	−14·751
β Libræ (*Zuben-el-Genubi*)	2	15 10 23·316	+ 3·2185	S 8 55 39·97	+13·531
α Coronæ ... (*Alphacca*)	2	15 29 28·846	+ 2·5388	N 27 7 47·22	−12·313
α Serpentis ... ... (*Unuk*)	2.3	15 38 12·601	+ 2·9512	N 6 48 49·71	−11·579
ζ Ursæ Minoris	4.5	15 48 29·683	− 2·2591	N 78 10 17·27	−10·968
β^1 Scorpii	2	15 58 17·181	+ 3·4778	S 19 28 2·05	+10·175
δ Ophiuchi	3	16 7 53·978	+ 3·1359	S 3 22 33·59	+ 9·551
α Scorpii ... ... (Antares)	1.2	16 21 52·046	+ 3·6687	S 26 9 25·77	+ 8·354
η^2 Draconis	3.2	16 22 19·932	+ 0·8077	N 61 47 33·29	− 8·279
α Trianguli Australis	2	16 35 39·549	+ 6·2886	S 68 47 55·36	+ 7·292
ζ Herculis	3.2	16 36 39·022	+ 2·2628	N 31 49 36·63	− 6·682
κ Ophiuchi	3.4	16 51 50·729	+ 2·8339	N 9 34 3·97	− 5·854
ϵ Ursæ Minoris	4.5	16 58 37·959	− 6·3742	N 82 14 12·16	− 5·301
α^1 Herculis ... *Ras Algethi* (var.) ...	3.4	17 9 2·347	+ 2·7313	N 14 31 54·73	− 4·381
θ Ophiuchi	3.4	17 14 27·357	+ 3·6770	S 24 52 28·23	+ 3·937
β Draconis ... (*Alwaid*)	3.2	17 27 39·279	+ 1·3510	N 52 23 34·47	− 2·820
α Ophiuchi (*Ras Alhague*)	2	17 29 13·457	+ 2·7789	N 12 39 4·08	− 2·883
μ Herculis	3.4	17 41 38·700	+ 2·3438	N 27 47 37·35	− 2·343
γ Draconis ... (*Etanim*)	2.3	17 53 44·998	+ 1·3919	N 51 30 13·74	− 0·585
μ Sagittarii	4	18 6 24·361	+ 3·5837	S 21 5 20·79	− 0·554
δ Ursæ Minoris	4.5	18 12 0·905	−19·4070	N 86 36 29·24	+ 1·065
σ Octantis	6	18 19 13·643	+109·7715	S 89 16 33·20	− 1·961
α Lyræ ... ... (Vega)	1	18 32 46·432	+ 2·0303	N 38 40 12·21	+ 3·139
β^1 Lyræ ... ... (*Sheliak*) (var.) ...	4	18 45 32·309	+ 2·2119	N 33 13 15·13	+ 3·930
ζ Aquilæ	3	18 59 45·301	+ 2·7519	N 13 40 55·44	+ 5·102
δ Aquilæ	3.4	19 19 17·707	+ 3·0232	N 2 52 15·72	+ 6·903
h^2 Sagittarii	5.4	19 29 13·161	+ 3·6550	S 25 9 10·78	− 7·634
γ Aquilæ ... (*Tarazed*)	3	19 40 24·721	+ 2·8529	N 10 18 52·99	+ 8·509
α Aquilæ ... (Altair)	1.2	19 44 46·899	+ 2·9281	N 8 32 41·10	+ 9·234
β Aquilæ ... (*Alshain*)	4	19 49 16·246	+ 2·9473	N 6 6 3·02	+ 8·735
α^2 Capricorni (*Secunda Giedi*)	3.4	20 11 13·672	+ 3·3311	S 12 55 28·96	−10·868
α Pavonis	2	20 15 54·742	+ 4·7913	S 57 7 35·49	−11·181
α Cygni ... ... (*Arided*)	2.1	20 37 14·304	+ 2·0416	N 44 50 29·45	+12·705
32 Vulpeculæ	5.6	20 49 19·070	+ 2·5538	N 27 35 26·28	+13·505
61^1 Cygni	5.6	21 1 22·871	+ 2·6734	N 38 8 43·32	+17·481
ζ Cygni	3	21 7 42·060	+ 2·5480	N 29 43 23·19	+14·581
α Cephei ... ... (*Alderamin*)	3.2	21 15 38·555	+ 1·4361	N 62 3 52·32	+15·125
β Aquarii ... (*Sadalsund*)	3	21 25 4·895	+ 3·1608	S 6 6 40·76	−15·646
β^2 Cephei ... (*Alphirk*)	3	21 27 4·000	+ 0·7963	N 70 1 14·41	+15·713
ϵ Pegasi ... ... (*Enif*)	2.3	21 38 8·718	+ 2·9481	N 9 18 42·33	+16·336
α Aquarii ... (*Sadalmelik*)	3	21 59 27·866	+ 3·0800	S 0 55 0·32	−17·324
α Gruis	2	22 0 28·436	+ 3·8111	S 47 33 19·60	−17·209
η Aquarii	4.3	22 29 2·050	+ 3.0820	S 0 45 3·44	−18·436
ζ Pegasi ... (*Homan*)	3.4	22 35 19·577	+ 2·9865	N 10 11 22·91	+18·702
α Piscis Australis (Fomalhaut)	1.2	22 50 50·956	+ 3·3261	S 30 16 26·05	−18·968
α Pegasi ... ... (Markab)	2	22 58 38·042	+ 2·9836	N 14 32 37·77	+19·320
γ Piscium	4	23 10 47·276	+ 3·1063	N 2 36 36·70	+19·584
γ Cephei ... ...(*Errai*)	3.4	23 34 18·719	+ 2·4077	N 76 56 44·69	+20·079
ω Piscium	4	23 52 59·707	+ 3·0779	N 6 10 56·03	+19·914

TABLE II.

MEAN TIMES OF TRANSIT OF THE PRINCIPAL STARS.

R. A.	Dec.	Stars' Name.	Jan. 1.	Feb. 1.	Mar. 1.	Apr. 1.	May 1.	June 1.
h. m.	° ′		h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
0 2	28 25 N	α Andromedæ (*Alpherat*)	5 16	3 15	1 24	23 18	21 21	19 19
0 7	14 30 N	γ Pegasi (Algenib)	21	20	29	23	26	24
0 19	77 57 S	β Hydri	34	33	42	36	39	37
0 34	55 52 N	α Cassiopeiæ	48	46	56	50	53	51
0 37	18 40 S	β Ceti	52	51	2 0	54	56	55
1 14	88 39 N	α Ursæ Minoris (Polaris)... ...	6 19	4 17	2 27	0 25	22 23	20 22
1 18	8 49 S	θ Ceti	32	30	40	38	36	35
1 33	57 52 S	α Eridani (Achernar)	48	46	56	54	52	51
2 0	22 53 N	α Arietis (*Hamel*)	7 14	5 12	3 22	1 20	23 18	21 17
2 37	2 43 N	γ^2 Ceti	51	50	59	57	55	54
2 56	3 36 N	α Ceti	8 10	6 8	4 17	2 16	0 18	22 12
3 16	49 25 N	α Persei (*Mirfak*)	29	27	36	35	37	31
3 46	23 43 N	η Tauri	54	53	5 2	3 0	1 2	56
3 52	13 52 S	γ^1 Eridani	9 7	7 6	15	13	15	23 9
4 29	16 16 N	α Tauri (Aldebaran)	43	41	50	49	51	45
5 8	45 52 N	α Aurigæ (Capella)	10 20	8 19	6 28	4 26	2 29	0 27
5 9	8 21 S	β Orionis (Rigel)	22	21	30	28	31	29
5 19	28 30 N	β Tauri (*Nath*)	32	31	40	38	41	39
5 26	0 24 S	δ Orionis	39	38	47	45	48	46
5 27	17 55 S	α Leporis	41	40	49	47	50	48
5 30	1 17 S	ϵ Orionis (middle star of belt) ...	10 43	8 42	6 51	4 49	2 52	0 50
5 35	34 8 S	α Columbæ	49	48	57	55	58	56
5 49	7 23 N	α Orionis (*Betelguex*)	11 2	9 1	7 10	5 8	3 11	1 9
6 16	22 34 N	μ Geminorum	29	28	37	35	38	36
6 21	52 38 S	α Argûs (Canopus)	36	35	44	42	45	43
6 40	16 33 S	α Canis Majoris (Sirius)	11 53	9 52	8 1	5 59	4 1	2 0
6 42	87 14 N	51 Cephei	55	54	3	6 1	3	2
6 54	28 48 S	ϵ Canis Majoris	12 8	10 6	16	14	16	15
7 13	22 12 N	δ Geminorum	26	24	34	32	34	33
7 27	32 9 N	α^2 Geminorum (Castor)	40	38	48	46	48	47
7 33	5 32 N	α Canis Minoris (Procyon) ...	12 46	10 44	8 54	6 52	4 54	2 53
7 38	28 19 N	β Geminorum (Pollux)	51	49	59	57	59	58
8 2	23 57 S	15 Argûs (Navis)	13 16	11 14	9 24	7 22	5 24	3 23
8 40	6 52 N	ϵ Hydræ	54	52	10 2	8 0	6 2	4 1
8 51	48 31 N	ι Ursæ Majoris	14 4	12 2	12	10	12	11
9 14	58 46 S	ι Argûs	14 28	12 26	10 35	8 34	6 36	4 34
9 22	8 8 S	α Hydræ (*Alphard or Cor Hydræ*)	35	33	42	41	43	41
9 25	52 14 N	θ Ursæ Majoris	38	36	45	44	46	44
9 39	24 20 N	ϵ Leonis	52	50	59	58	7 0	58
10 2	12 34 N	α Leonis (Regulus)	15 15	13 13	11 22	9 21	22	5 21
10 13	20 28 N	γ^1 Leonis	15 26	13 24	11 33	9 32	7 34	5 32
10 40	59 2 S	η Argûs	52	52	12 1	10 0	8 2	6 0
10 56	62 25 N	α Ursæ Majoris (*Dubhe*)	16 8	14 7	16	14	17	15
11 8	21 12 N	δ Leonis	20	19	28	26	29	27
11 13	14 7 S	δ Crateris	26	25	34	32	35	33
11 43	15 16 N	β Leonis (*Denebola*)	16 55	14 54	13 3	11 1	9 4	7 2
11 47	54 23 N	γ Ursæ Majoris (*Megrez*)	17 0	59	8	6	8	7
12 11	78 38 S	β Chamæleontis	23	15 22	31	29	32	30
12 20	62 25 S	α^1 Crucis	32	31	40	38	41	39
12 28	22 43 S	β Corvi	40	39	48	46	49	47

MEAN TIMES OF TRANSIT OF THE PRINCIPAL STARS.

R. A.	Dec.	Stars' Name.	July 1.	Aug. 1.	Sep. 1.	Oct. 1.	Nov. 1.	Dec. 1.
h. m.	° ′		h m.	h m.	h m.	h m.	h m.	h m.
0 2	28 25 N	α Andromedæ (*Alpherat*)	17 20	15 19	13 17	11 19	9 16	7 18
0 7	14 30 N	γ Pegasi (Algenib)	25	24	22	24	21	23
0 19	77 57 S	β Hydri	38	37	35	37	34	36
0 34	55 52 N	α Cassiopeiæ	52	51	49	51	48	50
0 37	18 40 S	β Ceti	56	55	53	55	52	54
1 14	88 39 N	α Ursæ Minoris (Polaris)... ...	18 32	16 31	14 29	12 31	10 29	8 31
1 18	8 49 S	θ Ceti	36	34	33	35	32	34
1 33	57 52 S	α Eridani (Achernar)	52	50	49	51	48	50
2 0	22 53 N	α Arietis (*Hamel*)	19 18	17 16	15 15	13 17	11 14	9 16
2 37	2 43 N	γ^2 Ceti	55	53	52	54	51	53
2 56	3 36 N	α Ceti	20 14	18 12	16 10	14 13	12 10	10 12
3 16	49 25 N	α Persei (*Mirfak*)	33	31	29	32	29	31
3 40	23 43 N	η Tauri	58	56	54	57	54	56
3 52	13 52 S	γ^1 Eridani	21 11	19 9	17 7	15 10	13 7	11 9
4 29	16 16 N	α Tauri (Aldebaran)	47	45	43	46	43	45
5 8	45 52 N	α Aurigæ (Capella)	22 24	20 23	18 21	16 23	14 21	12 23
5 9	8 21 S	β Orionis (Rigel)	26	25	23	25	23	25
5 19	28 30 N	β Tauri (*Nath*)	36	35	33	35	33	35
5 26	0 24 S	δ Orionis	43	42	40	42	40	42
5 27	17 55 S	α Leporis	45	44	42	44	42	44
5 30	1 17 S	ϵ Orionis (middle star of belt) ...	22 47	20 46	18 44	16 46	14 44	12 46
5 35	34 8 S	α Columbæ	53	52	50	52	50	53
5 49	7 23 N	α Orionis (*Betelguex*)	23 6	21 5	19 3	17 5	15 3	13 5
6 16	22 34 N	μ Geminorum	33	32	30	32	30	32
6 21	52 38 S	α Argûs (Canopus)	40	39	37	39	37	39
6 40	16 33 S	α Canis Majoris (Sirius)	0 2	22 0	19 58	18 0	15 58	14 0
6 42	87 14 N	51 Cephei	3	1	59	1	16 0	1
6 54	28 48 S	ϵ Canis Majoris	16	4	20 12	14	11	14
7 13	22 12 N	δ Geminorum	34	32	30	31	28	31
7 27	32 9 N	α^2 Geminorum (Castor)	48	46	45	46	44	46
7 33	5 32 N	α Canis Minoris (Procyon) ...	0 54	22 52	20 51	18 53	16 50	14 51
7 38	28 19 N	β Geminorum (Pollux)	59	57	55	57	54	55
8 2	23 57 S	15 Argûs (Navis)	1 24	23 22	21 20	19 22	17 19	15 20
8 40	6 52 N	ϵ Hydræ	2 2	0 0	59	20 0	58	59
8 51	48 31 N	ι Ursæ Majoris	12	10	22 9	10	18 8	16 9
9 14	58 46 S	ι Argûs	2 36	0 34	22 32	20 35	18 31	16 33
9 22	8 8 S	α Hydræ (*Alphard or Cor Hydræ*)	43	41	39	42	38	40
9 25	52 14 N	θ Ursæ Majoris	46	44	42	45	41	43
9 39	24 20 N	ϵ Leonis	3 0	58	56	59	56	58
10 2	12 34 N	α Leonis (Regulus)	23	1 21	23 19	21 22	19 19	17 21
10 13	20 28 N	γ^1 Leonis	3 34	1 32	23 26	21 29	19 26	17 28
10 40	59 2 S	η Argûs	4 1	2 0	54	56	54	56
10 56	62 25 N	α Ursæ Majoris (*Dubhe*)	16	15	0 13	22 11	20 9	18 11
11 8	21 12 N	δ Leonis	28	27	25	23	21	23
11 13	14 7 S	δ Crateris	34	33	31	29	27	29
11 43	15 16 N	β Leonis (*Denebola*)	5 3	3 2	1 0	22 58	20 56	18 58
11 47	54 23 N	γ Ursæ Majoris (*Megrez*)	8	7	5	23 3	21 1	19 3
12 11	78 38 S	β Chamæleontis	31	30	28	26	24	26
12 20	62 25 S	α^1 Crucis	40	39	37	35	33	35
12 28	22 43 S	β Corvi	48	47	45	43	41	43

TABLE II.

MEAN TIME OF TRANSIT OF THE PRINCIPAL STARS.

R. A.	Dec.	Stars' Name.	Jan. 1.	Feb. 1.	Mar. 1.	Apr. 1.	May 1.	June 1.
h. m.	° ′		h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
12 50	38 59 N	α Canum Venaticorum	18 3	16 1	14 11	12 9	10 11	8 10
13 18	10 31 S	α Virginis (Spica)	31	29	39	37	39	38
13 43	49 56 N	η Ursæ Majoris (*Benetnasch*) ...	55	53	15 3	13 1	11 3	9 2
13 49	19 1 N	η Bootis	19 1	59	9	7	9	8
13 55	59 47 S	β Centauri	7	17 5	15	13	15	14
14 10	19 49 N	α Bootis (Arcturus)	19 23	17 21	15 31	13 29	11 31	9 30
14 31	60 19 S	α^2 Centauri	43	41	51	49	51	50
14 40	27 36 N	ϵ^2 Bootis	52	50	16 0	58	12 0	59
14 44	15 32 S	α Libræ	56	54	4	14 2	4	10 3
14 51	74 39 N	β Ursæ Minoris	20 5	18 3	13	11	13	12
15 10	8 56 S	β Libræ	20 23	18 21	16 30	14 29	12 31	10 30
15 29	27 8 N	α Coronæ Borealis	42	40	49	48	50	48
15 38	6 49 N	α Serpentis	51	49	58	57	59	57
15 48	78 10 N	ζ Ursæ Minoris	21 4	19 2	17 11	15 10	13 12	11 10
15 58	19 28 S	β^1 Scorpii	10	8	17	16	18	16
16 8	3 23 S	δ Ophiuchi	21 20	19 18	17 27	15 26	13 28	11 26
16 22	26 9 S	α Scorpii (Antares)	34	32	41	40	42	40
16 22	61 48 N	η^2 Draconis	36	34	43	42	44	42
16 36	68 48 S	α Trianguli Australis	46	44	53	52	54	52
16 59	82 14 N	ϵ Ursæ Minoris	22 16	20 14	18 23	16 22	14 24	12 22
17 9	14 32 N	α^1 Herculis	22 22	20 20	18 29	16 28	14 30	12 28
17 28	52 21 N	β Draconis	44	42	51	48	49	47
17 29	12 39 N	α Ophiuchi	45	43	52	49	50	48
17 54	51 30 N	γ Draconis	23 5	21 4	19 17	17 16	15 17	13 15
18 6	21 5 S	μ Sagittarii	18	17	26	24	27	25
18 12	86 36 N	δ Ursæ Minoris	23 21	21 22	19 31	17 29	15 31	13 31
18 19	89 17 S	σ Octantis	29	29	38	37	40	39
18 33	38 40 N	α Lyræ (Vega)	45	44	53	51	53	52
18 46	33 13 N	β^1 Lyræ	57	56	20 5	18 3	16 5	14 4
19 0	13 41 N	ζ Aquilæ	0 15	22 13	23	21	22	21
19 19	2 52 N	δ Aquilæ	0 35	22 33	20 42	18 40	16 42	14 41
19 40	10 19 N	γ Aquilæ	56	54	21 2	58	17 0	59
19 45	8 33 N	α Aquilæ (Altair)	1 0	58	6	19 2	4	15 3
19 47	88 56 N	λ Ursæ Minoris	1	59	8	6	8	7
19 49	6 6 N	β Aquilæ	5	23 3	9	7	9	8
20 11	12 55 S	α^2 Capricorni	1 27	23 25	21 34	19 31	17 33	15 31
20 16	57 8 S	α Pavonis	31	28	38	36	38	37
20 37	44 50 N	α Cygni	53	47	57	55	57	56
21 1	38 9 N	61^1 Cygni	2 17	0 15	22 21	20 19	18 21	16 19
21 8	29 43 N	ζ Cygni	23	21	27	25	27	25
21 16	62 4 N	α Cephei	2 32	0 30	22 35	20 35	18 36	16 34
21 25	6 7 S	β Aquarii	40	38	43	42	44	42
21 27	70 1 N	β^2 Cephei	44	42	47	46	48	46
21 38	9 19 N	ϵ Pegasi	54	52	57	56	58	56
21 59	0 55 S	α Aquarii	3 15	1 13	23 18	21 17	19 19	17 17
22 0	47 33 S	α Gruis	3 15	1 13	23 18	21 17	19 19	17 17
22 35	10 11 N	ζ Pegasi	51	49	54	53	55	53
22 51	30 16 S	α Piscis Australis (Fomalhaut) ...	4 5	2 4	0 13	22 7	20 10	18 8
22 59	14 33 N	α Pegasi (Markab)	13	12	21	15	18	16
23 34	4 58 N	ι Piscium	48	47	56	50	53	51

MEAN TIME OF TRANSIT OF THE PRINCIPAL STARS.

R. A.	Dec.	Stars' Name.	July 1.	Aug. 1.	Sep. 1.	Oct. 1.	Nov. 1.	Dec. 1.
h. m.	° ′		h. m.	h. m.	h. m.	h. m.	h. m	h. m.
12 50	38 59 N	α Canum Venaticorum	6 11	4 9	2 8	0 10	22 3	20 6
13 18	10 31 S	α Virginis (Spica)	39	37	36	38	31	34
13 43	49 56 N	η Ursæ Majoris (*Benetnasch*) ...	7 3	5 1	3 0	1 2	55	58
13 49	19 1 N	η Bootis	9	7	6	8	23 1	21 4
13 55	59 47 S	β Centauri	15	13	12	14	7	10
14 10	19 49 N	α Bootis (Arcturus)	7 31	5 29	3 28	1 30	23 23	21 26
14 31	60 19 S	α^2 Centauri	51	49	48	50	43	46
14 40	27 36 N	ϵ^2 Bootis	8 0	58	57	59	52	55
14 44	15 32 S	α Libræ	4	6 2	4 1	2 3	56	59
14 51	74 39 N	β Ursæ Minoris	13	11	10	12	0 8	22 7
15 10	8 56 S	β Libræ	8 31	6 29	4 27	2 30	0 27	22 25
15 29	27 8 N	α Coronæ Borealis	50	48	46	49	46	44
15 38	6 49 N	α Serpentis	59	57	55	58	55	53
15 48	78 10 N	ζ Ursæ Minoris	9 12	7 10	5 8	3 11	1 9	23 6
15 58	19 28 S	β^1 Scorpii	18	16	14	17	15	12
16 8	3 23 S	δ Ophiuchi	9 28	7 26	5 24	3 27	1 25	23 22
16 22	26 9 S	α Scorpii (Antares)	42	40	38	41	38	36
16 22	61 48 N	η^2 Draconis	44	42	40	43	40	38
16 36	68 48 S	α Trianguli Australis	54	52	50	53	50	48
16 59	82 14 N	ϵ Ursæ Minoris	10 18	8 17	6 14	4 17	2 15	0 16
17 9	14 32 N	α^1 Herculis	10 29	8 28	6 26	4 28	2 26	0 28
17 28	52 24 N	β Draconis	48	47	45	47	45	47
17 29	12 39 N	α Ophiuchi	49	48	46	48	46	48
17 54	51 30 N	γ Draconis	11 13	9 14	7 10	5 11	3 10	1 12
18 6	21 5 S	μ Sagittarii	26	25	23	25	23	25
18 12	86 36 N	δ Ursæ Minoris	11 32	9 30	7 28	5 30	3 27	1 29
18 19	89 17 S	σ Octantis	42	40	37	38	36	37
18 33	38 40 N	α Lyræ (Vega)	53	52	50	52	50	52
18 46	33 13 N	β^1 Lyræ	12 5	10 4	8 2	6 4	4 2	2 4
19 0	13 41 N	ζ Aquilæ	22	21	19	21	18	20
19 19	2 52 N	δ Aquilæ	12 42	10 41	8 39	6 41	4 38	2 40
19 40	10 19 N	γ Aquilæ	13 0	58	57	59	56	59
19 45	8 33 N	α Aquilæ (Altair)	4	11 2	9 1	7 3	5 0	3 3
19 47	88 56 N	λ Ursæ Minoris	8	5	4	5	2	4
19 49	6 6 N	β Aquilæ	9	7	6	8	5	8
20 11	12 55 S	α^2 Capricorni	13 33	11 30	9 29	7 31	5 28	3 30
20 16	57 8 S	α Pavonis	38	35	33	35	32	34
20 37	44 50 N	α Cygni	57	55	54	56	53	56
21 1	38 9 N	61^1 Cygni	14 21	12 19	10 17	8 20	6 17	4 20
21 8	29 43 N	ζ Cygni	27	25	23	26	33	26
21 16	62 4 N	α Cephei	14 36	12 34	10 32	8 35	6 32	4 35
21 25	6 7 S	β Aquarii	44	42	40	43	40	43
21 27	70 1 N	β^2 Cephei	48	46	44	47	44	46
21 38	9 19 N	ϵ Pegasi	58	56	54	57	54	56
21 59	0 55 S	α Aquarii	15 19	13 17	11 15	9 18	7 15	5 17
22 0	47 33 S	α Gruis	15 19	13 17	11 15	9 18	7 15	5 17
22 35	10 11 N	ζ Pegasi	58	57	51	54	51	53
22 51	30 16 S	α Piscis Australis (Fomalhaut) ...	16 9	14 8	12 6	10 9	8 6	6 8
22 59	14 33 N	α Pegasi (Markab)	17	16	14	16	14	16
23 34	4 58 N	ι Piscium	52	51	49	51	49	51

TABLE III.

ACCELERATION:—For converting MEAN SOLAR TIME into SIDEREAL TIME.

HOURS.		MINUTES.		SECONDS.	
Hours of Mean Time.	Sidereal Time.	Minutes of Mean Time.	Sidereal Time.	Seconds of Mean Time.	Sidereal Time.
	m. s.		s.		s.
1	0 9·86	1	0·16	1	0·00
2	0 19·71	2	0·33	2	0·01
3	0 29·57	3	0·49	3	0·01
4	0 39·43	4	0·66	4	0·01
5	0 49·28	5	0·82	5	0·01
6	0 59·14	6	0·99	6	0·02
7	1 9·00	7	1·15	7	0·02
8	1 18·85	8	1·31	8	0·02
9	1 28·71	9	1·48	9	0·02
10	1 38·56	10	1·64	10	0·03
11	1 48·42	11	1·81	11	0·03
12	1 58·28	12	1·97	12	0·03
13	2 8·13	13	2·14	13	0·04
14	2 17·99	14	2·30	14	0·04
15	2 27·85	15	2·46	15	0·04
16	2 37·70	16	2·63	16	0·04
17	2 47·56	17	2·79	17	0·05
18	2 57·42	18	2·96	18	0·05
19	3 7·27	19	3·12	19	0·05
20	3 17·13	20	3·29	20	0·05
21	3 26·99	21	3·45	21	0·06
22	3 36·84	22	3·61	22	0·06
23	3 46·70	23	3·78	23	0·06
24	3 56·56	24	3·94	24	0·07
		25	4·11	25	0·07
		26	4·27	26	0·07
		27	4·44	27	0·07
		28	4·60	28	0·08
		29	4·76	29	0·08
		30	4·93	30	0·08
		31	5·09	31	0·08
		32	5·26	32	0·09
		33	5·42	33	0·09
		34	5·59	34	0·09
		35	5·75	35	0·10
		36	5·91	36	0·10
		37	6·08	37	0·10
		38	6·24	38	0·10
		39	6·41	39	0·11
		40	6·57	40	0·11
		41	6·74	41	0·11
		42	6·90	42	0·11
		43	7·06	43	0·12
		44	7·23	44	0·12
		45	7·39	45	0·12
		46	7·56	46	0·13
		47	7·72	47	0·13
		48	7·89	48	0·13
		49	8·05	49	0·13
		50	8·21	50	0·14
		51	8·38	51	0·14
		52	8·54	52	0·14
		53	8·71	53	0·15
		54	8·87	54	0·15
		55	9·04	55	0·15
		56	9·20	56	0·15
		57	9·36	57	0·16
		58	9·53	58	0·16
		59	9·69	59	0·16
		60	9·86	60	0·16

TABLE IV.

RETARDATION:—For converting SIDEREAL TIME into MEAN SOLAR TIME.

HOURS.		MINUTES.		SECONDS.	
Hours of Sidereal Time.	Mean Time.	Minutes of Sidereal Time.	Mean Time.	Seconds of Sidereal Time.	Mean Time.
	m. s.		s.		s.
1	0 9·83	1	0·16	1	0·00
2	0 19·66	2	0·33	2	0·00
3	0 29·49	3	0·49	3	0·01
4	0 39·32	4	0·66	4	0·01
5	0 49·15	5	0·82	5	0·01
6	0 58·98	6	0·98	6	0·02
7	1 8·81	7	1·15	7	0·02
8	1 18·64	8	1·31	8	0·02
9	1 28·47	9	1·47	9	0·02
10	1 38·30	10	1·64	10	0·03
11	1 48·13	11	1·80	11	0·03
12	1 57·95	12	1·97	12	0·03
13	2 7·78	13	2·13	13	0·04
14	2 17·61	14	2·29	14	0·04
15	2 27·44	15	2·46	15	0·04
16	2 37·27	16	2·62	16	0·04
17	2 47·10	17	2·78	17	0·05
18	2 56·93	18	2·95	18	0·05
19	3 6·76	19	3·11	19	0·05
20	3 16·59	20	3·28	20	0·05
21	3 26·42	21	3·44	21	0·06
22	3 36·25	22	3·60	22	0·06
23	3 46·08	23	3·77	23	0·06
24	3 55·91	24	3·93	24	0·07
		25	4·10	25	0·07
		26	4·26	26	0·07
		27	4·42	27	0·07
		28	4·59	28	0·08
		29	4·75	29	0·08
		30	4·91	30	0·08
		31	5·08	31	0·08
		32	5·24	32	0·09
		33	5·41	33	0·09
		34	5·57	34	0·09
		35	5·73	35	0·10
		36	5·90	36	0·10
		37	6·06	37	0·10
		38	6·23	38	0·11
		39	6·39	39	0·11
		40	6·55	40	0·11
		41	6·72	41	0·11
		42	6·88	42	0·12
		43	7·04	43	0·12
		44	7·21	44	0·12
		45	7·37	45	0·12
		46	7·54	46	0·13
		47	7·70	47	0·13
		48	7·86	48	0·13
		49	8·03	49	0·14
		50	8·19	50	0·14
		51	8·36	51	0·14
		52	8·52	52	0·14
		53	8·68	53	0·15
		54	8·85	54	0·15
		55	9·01	55	0·15
		56	9·17	56	0·15
		57	9·34	57	0·16
		58	9·50	58	0·16
		59	9·67	59	0·16
		60	9·83	60	0·16

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